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Genetic and environmental variation in quality of forage maize in Europe

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Abstract. Various forage maize hybrids were grown in 24 trials in Europe in 1985 and 1986 and harvested at silage maturity to investigate the variation in quality. Average apparent digestibility of organic matter of the whole crop was rather high at 73.5 % (range 64.7-81.4 %). Digestibility had a large genetic and a fair environmental component. Range in digestibility between locations was rather small (70.4-76.0 %), which reveals that nutritive value of forage maize can be as high in the warm Mediterranean regions as in cool Scandinavia. Genetic differences in digestibility within locations were rather great and amounted to about 8 % between the extremes on an average. Digestibility of the crop correlated best with digestibility of the cell-wall constituents of the stem. This research demonstrates that maize of 75 % digestibility can be grown in all countries, given good growing conditions. Digestibility can be raised to about 80 % by breeding for better digestible cell walls in the straw.

Key words: digestibility, cell-wall constituents, hybrids, quality, ear, stover, straw

Introduction. A cooperative European FAO sub-network on 'The nutritive value of the whole maize crop' was established some years ago. In 1985 and 1986 the programme concerned 24 variety trials distributed over the maize growing regions of Europe. Its aim was to study:
- the differences in nutritive value between hybrids and locations,
- the basic causes of the differences in nutritive value between the hybrids and locations.

Material and methods. Selected hybrids were grown at all locations following local recommendations for sowing date, plant density, application of fertilizer, etc. Plot size was usually 6 m × 6 m in 3 or 4 replicates. Harvesting was usually done at the silage stage (hard dough). Data were recorded on weather conditions, yield and morphological composition (% ear, % husk + shank, % stem + leaf) and nutritive value (cell-wall constituents and in vitro digestibility). Cell-wall constituents of 3 locations were determined by the Maize Research Institute, Zemun, Yugoslavia, and in vitro digestibility of all locations was measured by the Department of Field Crops and Grassland Science, Wageningen. All in vitro digestibility data were converted

to in vivo apparent digestibility of organic matter with the aid of standard samples of known in vivo digestibility that were included in all in vitro runs. This synopsis focuses on the digestibility studies.

Results and discussion. Yield varied considerably between locations. This is almost certainly caused by the different growing conditions (sunshine, temperature and water supply). Ear content between locations ranged from 41-55 %; it was on average 49 %. Average digestibility was high at 73.5 %, with a range of 64.7-81.4 % over all locations and hybrids. The variation in digestibility was explained for 86 % by genotype and location. Residual standard error was small at 1.28 %. This error even contains the genotype × environment interaction, which therefore must have been very small.

Table 1 presents the average digestibility of the various testing sites after correction for differences in hybrid choice. The range in digestibility between locations was rather small (70.1-76.0 %). The few low values are possibly due to very late harvest or severe drought. There was no indication that digestibility was lower at lower latitude or at higher growing temperature as had been expected from controlled environment studies (Struik, 1983; Deinum & Struik, 1986). This suggests that digestibility of forage maize can be as high in warmer as in cooler regions provided hybrids of proper maturity are selected.

Table 2 presents the average digestibility of the various hybrids over the locations. It shows a somewhat larger range, 71.3-78.7 %. The range was even greater (69.9-78.7 %) if hybrids that were only grown once were included. Ranking order of the standard hybrids (Eta Ipho, LG9, LG11 and Inra 260 bm3) was the same in

Table 1. Mean digestibility (%) at the different locations corrected for hybrid effects, omitting immature crops (<40 % ear).

Location	Digestibility (%)	
	1985	1986
Alnarp (SW)	73.1	
Braunschweig (FRG)	75.6	73.8
Wageningen (NL)	73.1	70.5
Paulinenaue (GDR)		73.5
Bernburg (GDR)	74.5	
Blonie (P)		70.1
Smolice (P)		74.8
Peronne (F)	76.0	
Lusignan (F)	74.9	73.8
Vienna (AU)	72.4	72.4
Zürich (CH)		73.5
Padova (I)	72.2	
Zemun (YU)	70.4	71.8
Fundulea (RU)	70.4	70.8
La Coruña (SP)	75.7	74.7
Saloniki (H)	73.0	73.8

Table 2. Mean digestibility (%) of hybrids corrected for location effects, omitting immature crops (<40 % ear).

Hybrid	Digestibility					
	<73.0		73.0-74.0		>74.0	
	n^1	value	n	value	n	value
ZPSC 701	6	71.3*				
Eta Ipho	21	72.0				
MB 378	9	72.1				
Bekello	4	72.2				
Olymp	15	72.2				
Horreo 320	3	72.4				
Husar	2	72.4				
HTV 270	20	72.6				
Aris	7	72.8				
Alexandros			8	73.0		
SMH 640			10	73.1		
ZPTC 509			9	73.2		
Anko			6	73.6		
Dus 130			10	73.6		
ZPTC 196			2	73.7		
LG 1					5	74.2
Inra 260 bm1					8	74.3
LG 11					16	74.5
LG 9					9	75.4
Inra 260 bm3					17	78.7

[1] Number of data per hybrid.
* Residual standard error of individual measurement = 1.28 %.

all trials. All trials contained hybrids with even lower digestibility than the poorly digestible hybrid Eta Ipho.

Further analysis revealed that digestibility was usually not correlated with % ear within location, possibly because of lack of variation in % ear since crops were harvested at silage maturity. The correlations between digestibility and acid-detergent fibre, cell-wall constituents or acid-detergent lignin at the 3 locations studied (Braunschweig, Wageningen and Zemun) were low, and the corresponding regression lines differed with location. However, correlations between digestibility of organic matter of the whole crop and digestibility of the cell walls of the stem were high (0.6-0.96). This indicates that genetic variation in digestibility of forage maize at silage maturity is mainly due to genetic variation in cell-wall digestibility and not so much to cell-wall production and composition. This is in agreement with former findings.

Average digestibility could have reached 75 % in the contemporary sets of hybrids when grown under good conditions. This value can be increased to about 80 % by breeding for better digestible cell walls in the stover.

References

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This synopsis is based on two reports by B. Deinum, entitled 'Genetic and environmental variation in quality of forage maize in Europe in 1985' (Report No 91) and 'Genetic and environmental variation in quality of forage maize in Europe in 1986' (Report No 95). Department of Field Crops and Grassland Science, Wageningen Agricultural University, Wageningen/FAO, Rome; 1986. Report 91; 40 pp., 3 figs., 12 tables, 8 refs. Report 95: 38 pp., 12 tables, 9 refs. Available as paper copy (Report 91, order R087; Report 95, order R088; f 25 including postage each) at NARD c/o Pudoc, P.O. Box 4, 6700 AA Wageningen, Netherlands (telex 45015 blhwg nl).
