EFFECT OF GRAIN CONTENT IN CORN HYBRIDS ON NUTRITIVE VALUE OF WHOLE PLANT CORN SILAGE

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SUMMARY

Three commercial corn hybrids were used to study the effect of their grain content on the nutritive value of whole plant corn silage. Hybrids were harvested at dough stage of maturity, chopped and ensiled in plastic bags for eight weeks. Nutrients digestibility coefficients and nutritive values of corn silages were determined using barki rams. The yield of whole plant corn forage, silage, ear, grain and leave with husk crops per feddan increased significantly ($P<0.05$) with increasing grain content. The yield of stover and stalks were not significantly ($P>0.05$) affected by grain content in the hybrid. The relative contents of ear and grain increased, stover and stalks decreased significantly ($P<0.05$) with increasing grain content. The relative content of leaves was not significantly ($P>0.05$) affected by grain content. The percentage of ensiling weight losses decreased significantly ($P<0.05$) with increasing grain content.

The contents of DM, OM and NFE of whole plant corn forage and silage crops increased, but the contents of CP, CF, EE and ash decreased significantly ($P<0.05$) with increasing grain content. However, ensiling decreased the contents of DM, OM and NFE and increased the contents of CP, EE, CF and ash. In respect of silage quality, the concentrations of lactic, propionic and valeric acids increased, but the concentrations of TVFA's, acetic, isobutyric, butyric acids and ammonia-N decreased significantly ($P<0.05$) with increasing grain content of corn silage. The pH value and the concentrations of total organic and isovaleric acids were not significantly affected by grain content ($P>0.05$).

Whole plant corn silage DM intake by rams and the digestibilities of DM, OM and NFE and subsequently TDN and DE values increased, but the digestibilities of CP and CF and subsequently DCP value decreased significantly ($P<0.05$) with increasing grain content of corn silage. The digestibility of EE was not significantly affected by grain content ($P>0.05$). The production of TDN, DE and DCP per feddan along with the output of silage yield and economic efficiency increased significantly ($P<0.05$) with increasing grain content of corn silage. Also, the output per feddan was doubled by 1.18 to 1.36 when corn crop used as silage compared with grain. In addition, the corn crop can be harvested early to clear the land for fall plowing or for second cropping. These results suggest that the optimum level of grain in whole plant corn silage is at least 35% of the DM.

Key words: *Whole plant corn silage, quality characteristics, nutritive value and economic evaluation.*

INTRODUCTION

Corn silage is the most popular silage in the world where corn plant grows well because, maximum yields of digestible nutrients per unit of land can be harvested from this crop. In addition, the corn plant can also be handled harvesting at a convenient time of the year and over a period of time. High yielding grain varieties of corn generally produce maximal yields of digestible nutrients

(Church, 1991). Whole plant corn is a major and unique forage crop for silage production because of its high DM content, low buffering capacity and high level of soluble carbohydrates. These will normally ensure that adequate quantities of lactic acid are produced by fermentation to give a good preservation (Luther, 1986). There are many economic advantages in the production and use of corn silage, TDN yield is 30 - 50 % more than when crop is harvested as grain and stover. Ensiled corn crop can be kept for a long period of time without significant losses in nutritive values. Corn crop can be harvested early to clear the land for fall plowing or second cropping (Perry and Cecava, 1995).

The grain content of corn silage is frequently used as a quality trait. This seems logical, since the grain of corn is reputed to contain a higher energy concentration than the stover (Owen, 1967). Quality of corn silage is frequently equated with grain content of silage (Hemken *et al.*, 1971). Silage made from high yielding grain varieties and hybrids of corn generally produce maximal yields of digestible nutrients (Church, 1991 and Perry and Cecava, 1995).

The objective of the present study was to investigate the effect of grain content on the yield, chemical composition, quality characteristics, DM intake, nutrients digestibilities, the output obtained of TDN, DE and DCP along with economic efficiency of making whole plant corn silage.

MATERIALS AND METHODS

The current work was carried out at Sakha Animal Production Research Station, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture. Three commercial corn hybrids including *three way cross Pioneer-3057* (low in grain content, less than 25%), *three way cross 320* (medium in grain content,25-35%) and *single cross 10* (high in grain content, more than 35%) were used to study the effect of grain content on the yield, quality, digestibility, nutritive value and economic evaluation of corn silage. Three plots with an area of 4.2 m^2 for each hybrid were taken randomly to estimate the yield of whole plant corn forage per feddan. Representative samples from each plot were taken to estimate the yield of ear, grain, cob, fresh stover, stalks and leaves. These hybrids were harvested at dough stage of maturity and chopped into pieces with 1.0-1.5 cm of length. Five hundred kg of each chopped hybrid was ensiled in double plastic bags with 50 kg weight for each, pressed by hand to exclude the air and ensiled for eight weeks. The bags were reweighed after ensiling period to determine the yield of silage crop and ensiling weight losses.

Color and odor of silages were examined and samples were taken for chemical analysis. Silage samples were extracted using 20 g homogenized wet material with 100 ml distilled water in warm blender for 10 minutes (Waldo and Schultz, 1956). The homogenized sample was filtered through a double layer of cheese cloth and then the solution refilterated through a filter paper until it becomes perfectly clear. Silage pH was determined directly using 680 Orian digital pH meter. The concentrations of TVFA's were determined according to the method of Warner (1964), while lactic, acetic, propionic, isobutyric, butyric, isovaleric and valeric acids were determined using gas chromatography according to the method of Erwin *et al.* (1961) and ammonia-N according to the method of AOAC (1990).

Three digestibility trails were conducted to determine the nutrients digestibility coefficients and nutritive value of different corn hybrids silages using three barki rams with an average body weight of 50±0.50 kg and 3±0.05 years of age. Rams were housed individually in digestible carts for 15 days as a preliminary period followed by 7 days as a collection period. Digestible cartes permitted total collection and separation of feces and urine. Corn silage was offered to cover the maintenance requirements (NRC, 1985) in almost two equal meals daily at 8 a.m. and 4 p.m. The water was available in plastic buckets all day round. Samples of silages were taken at the beginning, middle and end of digestibility trails. Total collection of feces from each ram was weighed daily during the collection period and samples (10 % by weight) of each daily collection were taken. Samples of forage, silage and feces were dried in a forced air oven at 65°C for 48 hours, thoroughly mixed and representative samples were ground and chemically analyzed to determine the contents of CP, CF, EE and ash according to the methods of AOAC (1990).

Statistical analysis was carried out using general linear models procedure adapted by SPSS (1999) for user's guide with a one-way ANOVA.

RESULTS AND DISCUSSION

The yield of whole plant corn forage, silage, ear, grain and leaves increased significantly (P<0.05) with increasing grain content as shown in Table (1). The yield of stover and stalks were not significantly (P<0.05) affected by grain content. The relative contents of ear and grain increased and stover and stalks decreased significantly (P<0.05) with increasing grain content. The relative content of leaves was not significantly (P<0.05) affected by grain content. The percentage of ensiling losses decreased significantly (P<0.05) with increasing grain content. These results agreed with those obtained by Hemken *et al.* (1971) and Mahanna (1994) who found that the yield of silage crop and the percentage of ear and grain increased, while the contents of stover and stalks decreased with increasing grain content of the hybrid.

The chemical composition of whole plant corn forage and its silage as shown in Table (2) indicated that the contents of DM, OM and NFE increased and the contents of CP, CF, EE and ash decreased significantly (P<0.05) with increasing grain content. The previous results are in accordance with those obtained by Hemken *et al.* (1971) and Phipps *et al.* (1979) who reported that a high grain variety was higher in DM, but lower in CP, CF and EE contents. Joanning *et al.* (1981) showed that grain content of corn silage resulted in a dilution of fiber components. Mahanna (1994) stated that NFE content of corn silage increased with increasing grain content.

Ensiling had a pronounced effect on the chemical composition of corn forage, for which the contents of DM, OM and NFE decreased, while the contents of CP, CF, EE and ash increased after ensiling. The decrease of the content of some nutrients during ensiling may be due to the dissipation of carbohydrates to carbon dioxide and water as the result of respiration by both plant cells and aerobic microflora and the fermentation of carbohydrates by lactic acid bacteria along with effluent loss (Woolford, 1984). Fermentation characteristics of different whole plant corn silages indicated a good quality silage, which

Table (1): Yield of whole plant corn forage, silage and plant parts, ensiling losses and relative yield of plant parts.

Items	Grain content			
	Low	Medium	High	SE
Yield		(ton / feddan on DM basis)		
Forage crop*	4.59^{c}	5.49^{b}	6.46^{a}	0.20
Silage crop	4.29^{c}	5.21^{b}	6.17^{a}	0.20
Ensiling losses	0.30	0.28	0.29	0.01
Ear **	1.52^{c}	2.19^{b}	2.92^{a}	0.12
Grain	1.10^{c}	1.65^{b}	2.35^{a}	0.11
Cob	0.42^{b}	0.54^{a}	0.57^{a}	0.02
Stover***	3.07	3.30	3.54	0.10
Stalks	2.05	2.08	2.28	0.09
Leaves	1.02^{b}	1.22^{a}	1.26^{a}	0.04
Relative percentage of plant parts of forage crop yield				
Ensiling losses	6.64^{a}	5.18^{b}	4.56^{b}	0.27
Ear **	33.21^{c}	39.62^{b}	45.72^{a}	1.16
Grain	24.01^{c}	29.85^{b}	36.73^{a}	1.14
Cob	9.20^{b}	9.77^{a}	8.99^{b}	0.20
Stover***	66.79^{a}	60.38^{b}	54.28^{c}	1.16
Stalks	44.68^{a}	37.19^{b}	34.93^{c}	1.11
Leaves	22.11	23.19	19.35	0.88

*** Forage crop = ear + stover **Ear = grain + cob *** Stover = stalks + leaves**

a, b and c: values in the same row with different superscripts differ significantly (P<0.05).

Table (2): Chemical composition of whole plant corn forage and silage.

Items		Grain content			
		Low	Medium	High	SE
DM %	Forage	29.52^{b}	30.23^{b}	31.98^{a}	0.25
	Silage	29.12^{b}	29.76^{b}	30.98^{a}	0.22
Composition of DM %					
OM	Forage	93.95^{c}	94.99^{b}	95.71^{a}	0.19
	Silage	93.28^{b}	94.58^{b}	95.29^{a}	0.21
CP	Forage	8.51^{a}	8.02^{b}	7.62^{c}	0.10
	Silage	8.65^{a}	8.16^{b}	7.76^{c}	0.10
CF	Forage	25.24^{a}	23.45^{b}	20.79^{c}	0.42
	Silage	26.30^{a}	24.21^{b}	21.29^{c}	0.47
EE	Forage	3.22^{a}	2.86^{b}	2.76^{b}	0.07
	Silage	3.34^{a}	2.97^{b}	2.88^{b}	0.07
NFE	Forage	56.98^{c}	60.65^{b}	64.54^{a}	0.72
	Silage	55.00^{c}	59.24^{b}	63.37^{a}	0.81
Ash	Forage	6.05^{a}	5.01^{b}	4.29^{c}	0.19
	Silage	6.72^{a}	5.42^{b}	4.71^{c}	0.21

a, b and c: values in the same row with different superscripts differ significantly (P<0.05).

were free from signs of molds, characterized by suitable fermentation characteristics such as yellowish green color and good smell. Results in Table (3) show that the concentrations of lactic, propionic and valeric acids increased, but the concentrations of TVFA's, acetic, isobutyric and butyric acids and ammonia-N decreased significantly ($P<0.05$) with increasing grain content of corn silage. Grain content of corn silage did not significantly ($P>0.05$) affect pH value and the concentrations of total organic and isovaleric acids. These results agreed with those obtained by Phipps *et al.* (1979) who found that high grain corn silage contained more lactic and propionic acids and less acetic and butyric acids and NH_3-N than those of low grain silage.

Values similar to those given in Table (3) were found in previous studies conducted by Thomas *et al.* (1975), Shaver *et al.* (1984), Buttrey *et al.* (1986), Phillip and Hidalgo (1989), Stokes and Chen (1994), Etman *et al.* (1994) and Bendary *et al.* (2001). Values for NH_3-N concentration in different silages ranged from 0.051 to 0.095% of DM and from 4.07 to 6.88% of total-N, which were within the values obtained by Sheperd and Kung (1996) and Chen *et al.* (1994) who showed that NH_3-N concentration of corn silage ranged between 0.04 and 0.15 % of DM; McDonald *et al.* (1995) also recommended that NH_3-N % of total-N for good quality silage should be less than 10 %.

DM intake of whole plant corn silage by rams increased significantly ($P<0.05$) as its grain content increased. Results were 1121.67, 1212.00 and 1300.00 g DM / day for low, medium and high grain silages, respectively (Table 4). From these results and the composition and quality of tested silages (Tables 2 and 3) it can be concluded that the DM intake of corn silage decreased with increasing CF content and ammonia-N and butyric acid concentrations. The present results are in accordance with those obtained by Owen (1967), Worly *et al.* (1986) and McDonald *et al.* (1995).

The digestibility coefficients of DM, OM and NFE (Table 4) increased significantly ($P<0.05$) as grain content of corn silage increased. However, the digestibility coefficients of CP and CF decreased significantly ($P<0.05$) as grain content of corn silage increased (Table 4). The digestibility of EE was not significantly ($P>0.05$) affected by grain content. Moreover, the values of TDN and DE increased, but DCP value decreased significantly ($P<0.05$) with increasing grain content of corn silage. These results were in agreement with those obtained by Hemken *et al.* (1971) who reported that high grain corn variety silage had higher digestibilities of DM, OM and NFE and TDN value, but lower digestibilities of CP and CF compared with low grain variety. Mahanna (1994) stated that TDN value of corn silage increased with increasing grain content. Ramsey (1963) and Byers and Ormiston (1964) found that DCP value of corn silage decreased as the content of grain increased.

Results in Table (5) indicated that the yield of TDN, DE and DCP of whole plant corn silage per feddan increased significantly ($P<0.05$) with increasing grain content of corn silage. These results attributed to increasing the yield of corn silage crop with increasing grain content. These results were in accordance with those obtained by Hemken *et al.* (1971) and Mahanna (1994) who found that the yield of TDN of corn silage increased with increasing grain content. Bendary *et al.* (2001) reported that the yield of TDN,

Table (3): Quality characteristics of whole plant corn silage.

Items	Grain content			
	Low	Medium	High	SE
pH	3.95	3.82	3.89	0.04
		% on DM basis		
Total organic acids	7.50	7.30	7.34	0.02
TVFA's	3.30^{a}	2.65^{b}	2.07^{c}	0.11
Lactic acid	4.20^{b}	4.65^{ab}	5.27^{a}	0.17
Acetic acid	1.13^{a}	0.92^{b}	0.83^{b}	0.07
Propionic acid	0.11^{c}	0.22^{b}	0.29^{a}	0.03
Isobutyric acid	0.52^{a}	0.34^{b}	0.22^{c}	0.04
Butyric acid	1.32^{a}	0.92^{b}	0.37^{c}	0.09
Isovaleric acid	0.16	0.12	0.19	0.01
Valeric acid	0.06^{b}	0.13^{ab}	0.17^{a}	0.01
Ammonia-N	0.095^{a}	0.072^{ab}	0.051^{b}	0.005
		% of total-N		
Ammonia-N	6.88^{a}	5.42^{ab}	4.07^{b}	0.35

a, b and c: values in the same row with different superscripts differ significantly ($P<0.05$).

Table (4): Intake, nutrients digestibility coefficients and nutritive values of whole plant corn silage.

Items	Grain content			
	Low	Medium	High	SE
Silage intake (g DM / day)	1121.67^{c}	1212.00^{b}	1300.00^{a}	28.09
Digestibility coefficients %:				
DM	61.86^{c}	66.91^{b}	69.63^{a}	0.68
OM	65.19^{c}	68.88^{b}	71.69^{a}	0.59
CP	68.09^{a}	65.69^{ab}	64.54^{b}	0.61
CF	66.81^{a}	63.48^{ab}	61.50^{c}	0.92
EE	77.50	74.33	73.66	0.80
NFE	63.01^{c}	70.76^{b}	75.46^{a}	1.08
Nutritive values:				
TDN %	64.05^{c}	67.61^{b}	70.66^{a}	0.60
DE Mcal / kg DM	2.82^{c}	2.98^{b}	3.12^{a}	0.03
DCP %	5.89^{a}	5.38^{b}	5.02^{b}	0.11

a, b and c: values in the same row with different superscripts differ significantly ($P<0.05$).

Table (5): Yield of TDN, DE and DCP, output of grain and corn silage per feddan and economic efficiency.

Items	Grain content			
	Low	Medium	High	SE
Grain yield (ton)[1]	2.68[b]	3.38[a]	3.74[a]	0.11
TDN yield of grain (ton)[2]	2.20[b]	2.77[a]	3.07[a]	0.09
TDN yield of silage (ton)	2.75[c]	3.52[b]	4.36[a]	0.15
DE yield of silage (x 10^3 Mcal)[3]	12.12[c]	15.52[b]	19.22[a]	0.68
DCP yield of silage (kg)	252.40[b]	276.96[ab]	311.20[a]	9.21
TDN yield of silage %[4]	125.00[b]	127.07[b]	142.02[a]	2.37
Output of grain and stover yield (LE)[5]	2130.00[b]	2655.00[a]	2925.00[a]	85.93
Output of silage yield (LE)[6]	2515.24[c]	3219.51[b]	3987.80[a]	140.88
Economic efficiency[7]	1.18[b]	1.21[a]	1.36[a]	0.02

a, b and c: values in the same row with different superscripts differ significantly (P<0.05).

1- as reported by Agricultural Economics (2002).

2-TDN content of corn grain = 82% (NRC 2001).

3- DE (Mcal) = TDN x 4.409 (NRC 2001).

4- as % of TDN yield of grain.

5-Output of grain and stover yield = grain yield x price of grain (750 LE / ton) + price of stover (120 LE / fed.) as reported by Agricultural Economics and Statistics Institute (2002).

6- Output of silage yield = $\frac{\text{Silage TDN yield per fed. x price of 1-ton corn grain}}{\text{TDN content of corn grain (82\%)}}$

7- Economic efficiency = $\frac{\text{Output of silage yield}}{\text{Output of grain and stover yield}}$

DE and DCP of corn silage increased with increasing silage crop yield.

Moreover, silage produced more TDN and DE yield per feddan as compared with their production from the grains, with the relative increase being about 25.00 - 42.02 %. These results agreed with those obtained by Perry and Cecava (1995) who found that total digestible nutrients yield is 30 to 50 % more when corn crop is harvested as a silage compared with harvesting as grain and stover.

Data in Table (5) showed that the output of silage, grain and stover yield per feddan and economic efficiency increased significantly ($P<0.05$) with increasing grain content of corn silage. The output of ensiled corn crop per feddan was increased by 1.18 to 1.36 times in comparison with output as grain and stover. In addition, the corn crop can be harvested early to clear the land for fall plowing or for second cropping. These results were within the values obtained by Gaafar (2001) who found that output of silage ranged from 1844.60 to 4041.40 LE.

From this study it could be concluded that corn hybrids should have a grain content of at least 35% in order to maximise profits and output for TDN and digestible protein; furthermore, these relationships should be incorporated in the respective plant breeding programs in the future.

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تأثير محتوى الحبوب فى هجن الذرة على القيمة الغذائية لسيلاج النبات الكامل للذرة

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أجريت هذه الدراسة بمحطة بحوث الإنتاج الحيوانى بسخا-معهد بحوث الإنتاج الحيوانى- مركز البحوث الزراعية حيث استخدم فيها ثلاثة من هجن الذرة تختلف فى محتواها من الحبوب حصدت فى طور النضج العجينى و فرمت و حفظت فى أكياس بلاستيك لمدة ثمانية أسابيع و بعد ذلك غذى عليها الكباش البرقى الناضجة لتقدير معاملات الهضم و القيم الغذائية.

أظهرت النتائج المتحصل عليها زيادة إنتاجية الفدان من المحصول الطازج و السيلاج و الكيزان و الحبوب و الأوراق مع الغلاف و محتوى كل من الكيزان و الحبوب و نقص محتوى كل من الحطب و العيدان و الأوراق و النسبة المؤية للفقد أثناء عملية السيلجة معنويا (على مستوى ٠,٠٥) مع زيادة محتوى الحبوب. بينما إنتاجية الفدان من الحطب و العيدان و محتوى الأوراق لم تتأثر معنويا بمحتوى الحبوب.

زيادة محتوى كل من المادة الجافة و المادة العضوية و المستخلص الخالى من الأزوت و نقص محتوى كل من البروتين الخام و الألياف الخام و المستخلص الأثيرى و الرماد فى كل من المحصول الطازج و السيلاج معنويا (على مستوى ٠,٠٥) مع زيادة محتوى الحبوب. تؤدى عملية السيلجة إلى نقص محتوى كل من المادة الجافة و المادة العضوية و المستخلص الخالى من الأزوت و زيادة محتوى كل من البروتين الخام و الألياف الخام و المستخلص الأثيرى و الرماد.

زيادة تركيز أحماض اللاكتيك و البروبيونيك و الفاليريك و نقص تركيز الأحماض الدهنية الطيارة الكلية و أحماض الأسيتيك و الأيزوبيوتريك و البيوتريك و نيتروجين الأمونيا فى السيلاج معنويا (على مستوى ٠,٠٥) مع زيادة محتوى الحبوب. بينما قيمة درجة الحموضة و تركيز الأحماض العضوية الكلية و حمض الأيزوفاليريك لم تتأثر معنويا بمحتوى الحبوب فى سيلاج الذرة.

زيادة كمية المادة الجافة المأكولة من السيلاج بواسطة الكباش و كذلك معاملات هضم كل من المادة الجافة و المادة العضوية و المستخلص الخالى من الأزوت و بالتالى محتوى كل من مجموع المركبات الغذائية المهضومة و الطاقة المهضومة معنويا (على مستوى ٠,٠٥) مع زيادة محتوى الحبوب. بينما انخفض معامل هضم كل من البروتين الخام و الألياف الخام وكذلك محتوى البروتين الخام المهضوم معنويا مع زيادة محتوى الحبوب. أكثر من ذلك فان معامل هضم المستخلص الأثيرى لم يتأثر معنويا بمحتوى الحبوب فى سيلاج الذرة.

زيادة إنتاجية الفدان من مجموع المركبات الغذائية المهضومة و الطاقة المهضومة و البروتين الخام المهضوم و العائد من إنتاجية الفدان من مجموع المركبات الغذائية المهضومة و الكفاءة الاقتصادية معنويا (على مستوى ٠,٠٥) مع زيادة محتوى الحبوب. توضح دراسة الكفاءة الاقتصادية تضاعف عائد الفدان ١,١٨- ١,٣٦ مرة عند استخدام محصول الذرة كسيلاج مقارنة بالحبوب.