Differences in Nutrient Quality among Wheat, Barley and Rye for Forage

Byung-Sun Kwon
College of Agriculture and Life Science, Sunchon Nat'l Univ. Sunchon 540-742, Korea.

ABSTRACT

TO select the most suitable crop and variety of forage for nutrient quality at the southern part of Korea, the crop of wheat, barley and rye were grown from Oct. 1999 to June 2000.

Paldanghomil variety of rye crop was shown to have the highest chemical components in comparison to other varieties of crops used in this experiment. It showed relatively high content of crude protein and *in vitro* dry matter digestibility (IVDMD) and low content of NDF, ADF, cellulose and lignin. Therefore, it was concluded that paldanghomil of rye crop was the most suitable variety with high weight and high nutrient quality for forage in the southern part of Korea. The heritabilities of all nutrient quality characters were estimated to be high.

Kew words **:** Forage crop, heritability, nutrient quality.

INTRODUCTION

Winter wheat in a hardened condition has survived temperatures as low as -40°F. (-40℃) when protected by snow and probably as low as -25°F (-32℃). without snow protection. Spring wheat may survive tmperatures as low as 15°F.(9.5℃) in the early stages of growth. A light frost may cause sterility in wheat that has headed or is about to head. A light frost before wheat is fully mature produces blisters on the seed coat and stops further grain development. In general, spring wheat requires a frost-free period of about 100 days or more for safe production. Quick-maturing varieties may be grown where the frost-free period is 90 days or less in Canada and Alska, where long days hasten flowering.

Short days or high temperatures stimulate tillering and leaf formation but delay the flowering of wheat plants. Although wheat is a long-day plant, quick-maturing or photo-insensitive varieties can be grown to maturity in any day length ranging from the 12-hour days of the equatorial highlands of Ecuador and Kenya to the 20-hour days of the " land of the midnight sun" at Rampart, Alaska, latitude 66° N. Wheat plants grown quickly under continuous artificial light are poorly developed and produce small heads and very little grain.

Barley is grown throughout the more temperate regions of the world. It thrives in a cool climate. It will stand more heat under semiarid than under humid conditions. In the warmer climates barley is sown in the fall or winter. The best barley soils appear to be well drained loams. It produces a poor crop, especially in grain quality, on heavy poorly drained soils in regions of frequent rains. Light sandy soils are poor for barley

*Corresponding author : **Byung Sun Kwon,** E-mail: kbs@ sunchon.ac.kr

because growth often is erratic and, also, the crop is more likely to be ripened prematurely by drought. Barley is the most dependable cereal under extreme conditions of salinity, summer frost, or drought. Barley is unsuited to acid soils below pH6 because of resultant aluminum toxicity which also retards root growth. Calcium applications correct the toxicity and promote root growth. Improved winter-hardy rye varieties are the hardiest of all cereals.

The highest yields of rye usually are obtained on rich, well-drained loam soils. Rye is more productive than other grains on infertile, sandy, or acid soils. It is the only small-grain crop that succeeds on coarse sandy soils.

It is an especially good crop for drained marshlands and cutover areas of the southeastern states when brought under cultivation. Rye usually yields less grain than winter wheat under conditions favorable for the latter crop because of its shorter growing period, heavier straw growth, and lower spikelet fertility. However, rye usually is sown on poorer soils and with pooere seedbed preparation than is wheat. Much higher yields are obtained on fertile or fertilized soils under good cultural conditions. It is the only successful hay crop for the high desert soils of eastern Oregon. (Martin *et al.*, 1976)

MATERIALS AND METHODS

An experiment was conducted from Oct. 1999 to June 2000 at Sunchon National University. six varieties of three crops listed in Table 1 were used in this trial.

The complete randomized block design with variety as treatment was used and treatment was randomized in each of the three blocks. Each experimental unit was 12.5㎡(2.5m × 5m). 15kg/10a seeds were sown at upland soil with 120cm ridge width and 90cm seeding width on Oct. 20 Fertilizer was applied at the rate of 12-10-8 kg/10a of N-P_2O_5-K_2O. One third of the total N, total P_2O_5 and K_2O and manure of 1 MT/10a were incorporated into the soil before sowing and the rest of N fertilizer was applied in early-Mar.

Ten plants were randomly sampled from each plot at flowering stage, and plant length, number of leaves were measured. To determine yield, all the plants in 1 ㎡ from each plant were harvested by cutting at about 3 cm above soil level. After determining fresh yield, plant materials of avout 600 g were sampled and weights were measured after drying for 30 min at 105℃, then for 72 hour at 70℃ in a forced-air oven. Analyses of variance for the characters were used to calculate genetic and environmental variance components (Grafius *et al.*, 1952 ; Robinson *et al.*, 1949, 1951).

The dried samples were ground in a Wiley mill to pass through 18 mesh screen and stored 18℃ and then subject the chemical analysis. Kjeldahl procedure was used to estimate crude protein (CP) (AOAC, 1970). Contents of fiber such as neutral detergent fiber (NDF), acid detergent fiber(ADF), permanganate lignin (PL) and cellulose were determined by the procedure described in Goering and Van Soest (1970). The content of hemicellulose was estimated by the defference between NDF and ADF.

The procedure of pepsin-cellulase assay (Goto and Winson, 1977) was used to determine *in vitro* dry matter digestibility (IVDMD) and digestible dry matter yield(DDMV) was calculated by the product of ery matter yield and IVDMD.

RESULTS ARND DISCUSSION

Comparisons of crude protein and fiber. Varietal mean values of chemical components are listed in table 1 and the results from analyses of variance in table 2. As shown in table 1 and 2. varietal CP showed large variations from 14.13 to 19.55 percent and was significantly different at the 1% level.

Paldanghomil was higher in CP with 19.55 percent

Table 1. The chemical compononts of varieties in wheat, barley and rye

Crop	Variety	Chemical components of dry matter weight (%)					
		CP	NDF	ADF	Hemicellulose (NDF-ADF)	Cellulose	Lignin
Wheat	Urimil	18.32	30.46	19.49	10.97	16.47	2.92
	Geurumil	17.54	32.16	20.21	11.95	17.35	2.98
Barley	Olbori	14,26	33.61	21.10	12.51	18.15	3.13
	Gangbori	14.13	34.54	22.24	12.30	18.50	3.24
Rye	Paldanghomil	19.55	28.16	17.44	9.72	15.63	2.31
	Chilbohomil	18.33	29.36	18.46	9.90	16.26	2.62

Table 2. Genotypic variances(6²G), environmental variances(6²E), heritability and analysis of variance in chemical components of crops

Nutrient	6²G	6²E	h^2	Variance	
				Variety	Error
CP	8.92	1.21	89.14	32.58**	1.130
NDF	5.72	0.71	87.51	21.62**	0.812
ADF	5.13	0.37	91.73	17.89**	0.341
Hemicellulose (NDF-ADF)	4.17	0.01	98.14	4.13**	0.003
Cellulose	5.47	0.34	92.16	18.88**	0.343
Lignin	0.08	0.01	91.73	0.30**	0.006

※※ : Significance at 1%

※ : Significance at 5%.

Table3. The *in vitro* dry matter yield digestibility and digestible dry matter weight of varieties in wheat, barley and rye

Crop	Variety	IVDMD(%)	DDMW (g/plant)
Wheat	Urimil	72.11	771.2
	Geurumil	71.04	764.8
Barley	Olbori	70.24	728.4
	Gangbori	70.13	721.2
Rye	Paldanghomil	74.30	834.0
	Chilbohomil	73.27	790.1

Table 4. Genotypic variances(6²G), environmental variance (6²E), heritabilities (h^2), and analysis of variance in IVDMD and DDMW of crops

Characters	6²G	6²E	h^2	Variance	
				Variety	Error
IVDMD (0/0)	5.17	0.86	84.29	6.070**	0.891
DDMW (kg/10a)	201.33	78.78	70.74	680.43**	78.780

than any other variety in this trial. Varietal contents of fiber varied widely, NDF ranged from 28.16 to 34.54 precent, ADF from 17.44 to 22.24 percent, hemicellulose from 9.72 to 12.30 percent, cellulose from 15.63 to 18.50 percent and lignin from 2.31 to 3.24 percent Analyses of variance among varieties showed that varietal differences of all the variables were highly significant ($P < 0.01$) and Paldanghomil was lower in NDF, ADF, cellulose and lignin, The results in this experiment are in agreement with these reports. Judging from the results, forage rye would be a excellent forage crops with high content of CP and low of crude fiber. Paldanghomil is the superior variety with high nutrient quality in this experiment.

IVDMD AND DDMW : As shown in table 3 and 4, varietal values of IVDMD in forage wheat, barley and rye showed large variations. It ranged from 70.13 to 74.30 percent analyses of variance among varieties showed that varietal diffeences were highly singificant. Paldanghomil was the superior variety in IVDMD. DDMW varied widely from 721.2 to 834.0kg, 10a and varietal differences in DDMW was significant at the 1% level.

Paldanghomil was highest in DDMW in this experiment.

Genetic and environmental variances and heritability analyses of variance of all the chemical characters were used to estimate genetic and environmental variance and the results are presented in Table

Genetic variance components were much larger in magnitude than environmental variance components and hence the values of heritability were generally high in most of the variables. The values of heritability is all the varieties were high from 87.51 to 98.14 percent. The results indicate that selection effciency would generally be high in breeding genotypes with high nutrient quality.

Forage wheat, barley and rye is known to be relatively high in energy, content of protein and IVDMD, and low in content of crude fiber although variation due to variety and growth condition was observed.

In addition, it has been reported that IVDMD and content of crude protein decrease more or less and content of crude fiber increases as plants grow older(Berendonk, 1982a, 1982b, 1983a, 1983b).

LITERATURE CITED

Berendonk, C. 1982a. Effect of harvest date on yield and quality of spring and winter swede rape varieties grown as a catch crop. I. Yield, leaf : stem ratio and dry matter content. Wirts. Futter 28(2) : 156-165. via Herb. Abt. 53(6) : 1333, 1983.

Berendonk, C. 1982b. Influence of harvest date on yield and quality of spring and winter rape cultivars grown as catch crops. Part 2. Crude ash, crude fibre and crude protein content and digestibility of arganic matter. Wirts. Futter. 28(3) : 202-214. via Herb. Abst. 54(2-3) : 502, 1984.

Berendonk, C. 1983a. The effect of harvesting date on the yield and contect of nutrient and mineral substances in summer and winter rape varieties grown as a catch crop. Zeitschrift fur Acker-und Pflanzenbau. 152(2) : 125-134. via Herb. Abst. 54 : 4281, 1984.

Berendonk, C. 1983b. Which rape variety to use for fodder DLG-Mitteilungen. 98(10) : 578-580. via Herb. Abst. 54(2-3) : 598, 1984.

Ha, Y.W., J.J.hwang, B.R.Sung, S.Y.Lee, C.S.Park, J.H.Park, N.H.Song and Y.S.Kim. 1989. A new high forage yielding rye variety " Chilbohomil. RDA Journal of Agricultural Science. 31(2) : 56-60

Ha, Y.W., S.Y.Lee,H.S.Song, H.Y.Heu, J.H.Nam and B.R.Sung. 1992. New early maturing, semidwarf, lodging resistant, high yielding and good quality soft wheat variety " Urimil". RDA Journal of Agicultural

Science. 34(2) : 1-4.

Hwang,J.J., B.R.Sung, K.B.Youn, W.S.Ahn, J.H.Lee, K.Y.Chung and Y.S.Kim, 1985. Forage and TDN yield of several winter crops at different clipping date. Korean J.Crop sci 30(3) : 301-309.

Kim,C.H. and J.C. Chae. 1991. Effects of seeding rate on forage yield and feed value of rye in paddy field. Korean J. Crop sci. 36(6) : 513-520

Kim,C.H. and J.C. Chae. 1994. Effects of nitrogen fertilizer application level and cutting time on forage yield and feed value of rye in paddy field. Korean J.Crop Sci. 39(4) : 373-381.

Kwon B, S,2004 Effects of fertilizer Levels on dry matter yield and nutrient quality of forage rye. Korean J.Plant Res. 7(3) : 181-186.

Kwon B.S. 2004. Influence of plant density on growth, yield and nutritional quality of forage rye. Korean J.Plant Res. 7(3) : 170-173.

Kwon B.S. 2004. Varietal variation of productivity and nutriental quality of forage rye in spring sowing. SNU J. of Natural Sci. vol.23 : 1-6.

Kwon B.S. and D.Y.Shin. 2004. Influence of sowing and harvest date on yield and nutritional quality of forage rye. Korean J. Plant Res. 7(3) : 206-210.

Kwon B.S. and K.H.Hyun. 2004. Effects of topping methods on rootyield and major agronomic characteristics in Alisma plantago. Korean J.Plant Res. 7(3) : 211-215.

Lee. H.J, J.I. Yun, K.H. Lee and K.B.Lim. 1983. Canopy structure and light interception as related to forage growth and dry matter production in pure and mixture stands. Korean J. Crop Sci. 28(2) : 272-279.

Martin J.H., W.H.Leonard and D.L.Stamp. 1976. Principles of field crop production of Macmillan publishing Co.Inc. pp 430-503.

Yoon, Y.H., I.M.Song, K.H.Kwon, Y.K.Seong, S.Y.Kim and J.Y.Lee. 1988. Studies on the year variation of agronomic character, yield and yield stability for leading wheat and barley varieties. in Chungnam region of Kores. RDA Journal of Agricultural Science. 30(2) : 31-38.

Youn, K.B., C.W.Lee, Y.H. Chang, S.S. Lee and Y.K.Park. 1991. Forage yield and quality of whole crop barley, wheat and triticale. Korean J.Crop Sci. 36(6) : 496-500.

(Received Otc. 26, 2004)
(Accepted Dec. 19, 2004)