韓草誌(J. Korean Grassl. Sci.) 18(2) : 113~122, 1998

Effect of Planting Dates and Nitrogen Fertilization Rates on the Forage Yield and Feeding Value of Introduced Triticale

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播種期 및 窒素 施肥量이 導入 트리티케일의 收量 및 飼料價値에 미치는 影響

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적 요

파종기 및 질소 시비량이 도입 트리티케일의 수량 및 사료가치에 미치는 영향을 검토하여 양질 다수성의 whole crop silage용 사초를 생산하기 위한 적정 재배법을 구명하고자 실험한 결과를 요약하면 다음과 같다.

1. 파종기에 따른 트리티케일의 출수, 개화 및 호숙기는 조파할수록 유의하게 빨랐다.
2. 청예, 건물수량 및 건물률은 파종기간 유의성이 있었으며 조파할수록 증가되었다.
3. 조단백질, 조지방, 조섬유, 조회분, NFE 및 TDN 함량은 파종기간 유의성이 없었으나 TDN 수량은 파종기가 늦을수록 유의하게 감소되었다. 그러나 무기성분 함량은 파종기의 영향을 거의 받지 않았다.
4. 질소 시비량의 증가에 따라 트리티케일의 청예, 건물수량 및 건물률은 유의하게 증가되었고, 조단백질, 조지방, 조회분, NFE, TDN 함량 및 TDN 수량도 유의하게 증가되었으나 조섬유 함량은 감소되었다.

Ⅰ. INTRODUCTION

The production of herbage and hay in Korea has been difficult because they are produced during the rainy season and the productivity of herbage is lowered in the fall due to the cool climate. Therefore, study on silage and roughage production is needed to improve feed supply. Fresh forage production by cultivating winter cereals in idle or infertile land during winter could reduce the import of a concentrated feed from abroad and could be used as a silage for the time of deficient roughage.

Major forage crops such as corn, wheat, barley, rye and triticale have been used as soilage for livestock in Korea(Hwang et al., 1985: Kwon & Kim, 1992, 1994, 1995). However, winter cereals such as barley and rye tend to accumulate their dry matter continuously even after heading date(Kim et al., 1988). Thus, they need to be used as a whole crop silage by harvesting at the yellow ripe stage which reaches to the peak in dry matter and nutrient accumulation, rather than used as soilage(Hwang et al., 1985: Kim et al., 1988: Kim & Han, 1988: Park et al., 1979). Triticale for soilage can be used later than rye because it tends to be ripened late. Triticale appears to be more favorable for its usage as a whole crop silage than rye because it has

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characteristics of high yield, low cellulose content even after heading, the slow aging of leaf blade and high digestibility(Lee et al., 1985).

Therefore this study was carried out to evaluate the growth characteristics of triticales introduced from foreign countries and determine their forage productivity and feeding value depending on seeding dates and nitrogen fertilization rates.

Ⅱ. MATERIALS AND METHODS

1. Experiments on seeding date

This experiment was conducted on the field plot at Ansung University during 1996 and 1997. The chemical soil properties of the experimental field are presented in Table 1. Soil type and pH were silty clay loam and 6.2, respectively. Organic matter content was 2.0% and available phosphorus content was 73mg/kg. The contents of potassium, calcium, magnesium and cation exchange capacity (CEC) were 0.84, 3.0, 1.1, and 6.9 me/100g, respectively.

Varieties tested in this study were Prag 46/3 introduced from Canada, Prego and Presto from Poland, and Sinkihomil developed in Korea. The varieties were seeded on 1, 15 and 30 Oct. 1996. All cultivars were drill seeded in a split plot design with three replications and a 40 × 18cm spacing at a rate of 14kg/10a to each $6m^2$ plot. Seeding date was used as main plot and variety as subplot.

N, P_2O_5, and K_2O were applied at a rate of 12, 9, 7kg of N, P, K/10a, respectively. Compost was applied at 1,000kg/10a. All the phosphorus(P_2O_5) and potassium(K_2O) was applied and incorporated into the soil prior to seeding. A half of nitrogen was applied before seeding and the rest of nitrogen was applied as top dressing in the middle of March.

Table 1. Chemical soil properties of the experimental field.

pH	O.M.* (%)	P_2O_5 (mg/kg)	Ex. cations (me/100g)			C.E.C** (me/100g)
			K	Ca	Mg	
6.2	2.0	73	0.84	3.0	1.1	6.9

* OM : Organic Matter.

** C.E.C : Cation Exchange Capacity.

Examination of growth characteristics and sampling were made at the dough stage of development which is considered as the best harvesting time in terms of the silage quality and yield of rye(Ko et al., 1986, 1987). Triticales were harvested from $1m^2$ of each plot and weighed to measure fresh weight. A subsample(500g) was taken from the measured materials, dried for 72 hours at 75℃ in a forced air dryer and weighed to determine its percent dry matter.

The dried samples were ground in a Wiley Mill with 40-mesh screen for nutritive component analysis. Percent crude protein was calculated by multiplying the conversion factor of 6.25 to percent N following the method developed by Yoshida et al.(1972). Other components were analyzed by A.O.A.C. method(1984). Percent TDN was determined by following the method Choi and Lee(1985) described; TDN(%) = −17.2649 + 1.2120 × crude protein(%) + 0.8352 × NFE(%) + crude fat(%) + 0.4475 × crude fiber(%). TDN yield was calculated by multiplying dry matter yield × percent TDN.

2. Experiments on fertilization rate

The varieties used in this experiment were Prag 46/3 and Sinkihomil that showed the highest TDN yield in a preliminary study. The fertilization rates of nitrogen were 12, 16 and 20kg of N/10a with 9kg of P and 7kg of K/10a. All of phosphorus and potassium was applied as basal fertilizer. A half of nitrogen was applied prior to seeding and the rest of nitrogen was used as top dressing in the middle of March, respectively. The varieties were seeded on Oct. 10, 1996 in a split plot design with three replications. Fertilization rate was used as main plot and variety as subplot. All other experimental methods were the same as that of the seeding date study.

Ⅲ. RESULTS AND DISCUSSION

1. Effects of seeding dates on growth, yield and feeding value

1) Heading and flowering dates

The dates of heading, flowering and dough stage of triticale depending on seeding dates were shown in Table 2. Heading dates were significantly affected by seeding dates and varieties. The triticales that were seeded earlier show a tendency of earlier heading. When the seeding of the variety was delayed 15 days, their heading dates were delayed about 4 days. The average heading dates of varieties seeded on Oct. 30 were delayed about 12 days comparing to that of

Table 2. Effect of seeding dates and varieties on the heading, flowering date and dough stage of introduced triticales.

Seeding date	Variety	Heading date	Flowering date	Dough stage
October 1	Prag 46/3	May 16 (226)	May 27 (237)	Jun. 21 (261)
	Prego	〃 21 (231)	〃 30 (240)	〃 26 (266)
	Presto	〃 9 (219)	〃 22 (232)	〃 14 (254)
	Sinkihomil	〃 12 (222)	〃 24 (234)	〃 17 (257)
	Mean	〃 14 (224)	〃 26 (236)	〃 19 (259)
October 15	Prag 46/3	May 20 (215)	Jun. 1 (226)	Jun. 25 (250)
	Prego	〃 24 (219)	〃 3 (228)	〃 27 (252)
	Presto	〃 13 (208)	May 25 (290)	〃 18 (243)
	Sinkihomil	〃 15 (210)	〃 26 (221)	〃 20 (245)
	Mean	〃 18 (213)	〃 29 (224)	〃 23 (248)
October 30	Prag 46/3	May 27 (207)	Jun. 4 (214)	Jul. 2 (242)
	Prego	〃 29 (209)	〃 5 (215)	〃 4 (244)
	Presto	〃 27 (207)	〃 3 (213)	〃 2 (242)
	Sinkihomil	〃 19 (199)	〃 1 (211)	Jun. 24 (234)
	Mean	〃 26 (206)	〃 3 (213)	Jul. 1 (224)
LSD (0.05)	Seeding date(A)	** (2.74)	** (1.78)	** (4.48)
	Variety(B)	** (1.72)	** (1.44)	** (2.31)
	Interactions(A × B)	** (2.98)	NS (2.50)	** (4.07)

( ) : days from sowing to heading, flowering and dough stage, respectively.
** : significant at 1% level. NS : non-significant.

the tested varieties seeded on Oct. 1. Presto showed the earliest heading date (May. 9) among the varieties in an early seeding(Oct. 1). However, the heading date of Presto in a late seeding(Oct. 30) was delayed more than the average heading date of all the others. It indicates that the heading date of Presto was the most affected by seeding date among the varieties. On the other hand, Sinkihomil developed in Korea was the least affected variety by the seeding date. There were significant differences in the number of days required to reach the dough stage depending on seeding dates and varieties. The dough stage of development of varieties seeded on Oct. 1 came 12 days earlier than that of the varieties seeded on Oct. 30. Presto was the earliest variety to reach the dough stage in both early seeding date(Oct. 1) and late seeding date(Oct. 30), while Prego was the latest variety.

Kwon and Kim(1994) reported that the heading date of rye was delayed 3-4 days when its seeding was delayed 15 days. The similar results was obtained in this experiment with triticale. Considering all the results, Presto appears to be a useful variety for early harvesting because of its characteristics of early ripening, and Prego seems to be a favorable variety because its growth period from heading date to the dough stage was long enough to be used as a soilage. In addition, Sinkihomil seems to be appropriate for late seeding since it was the least affected variety by seeding date.

2) Soilage and dry matter production

Table 3 shows the effect of seeding date on the

Table 3. Effect of seeding dates and varieties on the plant height, forage fresh weight, forage dry weight and dry weight percentage of triticale harvested at dough satge.

Seeding date	Variety	Plant height	Forage fresh Wt.	Forage dry Wt.	Dry matter
		cm	kg/10a	kg/10a	%
October 1	Prag 46/3	115.5	4,121	1,430	34.7
	Prego	99.4	3,366	1,152	34.2
	Presto	91.2	2,898	915	31.6
	Sinkihomil	118.2	4,662	1,703	36.5
	Mean	105.1	3,762	1,300	34.3
October 15	Prag 46/3	111.0	3,963	1,303	32.9
	Prego	92.8	3,048	1,037	34.0
	Presto	90.2	2,605	814	31.3
	Sinkihomil	128.9	4,342	1,512	34.8
	Mean	105.7	3,499	1,167	33.3
October 30	Prag 46/3	115.0	3,623	1,136	31.4
	Prego	97.0	3,141	961	30.5
	Presto	94.9	2,591	758	29.3
	Sinkihomil	131.8	4,297	1,521	35.4
	Mean	109.7	3,413	1,094	31.6
LSD (0.05)	Seeding date (A)	NS	95.2	82.7	1.9
	Variety (B)	5.9	110.0	59.1	1.4
	Interactions(A × B)	NS	NS	NS	NS

NS : non-significant.

soilage and dry matter yield of triticale. There were significant differences in soilage yield by varieties and seeding dates. The soilage yield increased as seeding date became earlier. In contrast, there was no significant variety x seeding date interaction for soilage yield as well as dry forage weight and percent dry matter. Varieties, Sinkihomil and Prag 46/3, produced a great amount of soilage and dry matter, and had a high percent dry matter at any of seeding dates. However, Presto was inferior to other varieties. There was no significant difference in forage yield between early seeding and late seeding although there was significant difference among varieties by seeding dates. Because each variety was harvested at the dough stage of development disregarding seeding date.

The result of this study agreed with the report by Kwon and Kim(1992), which showed that when rye was harvested at 80% of heading, dry matter yield of rye significantly increased as its seeding date became earlier, but there was no interaction between variety and seeding date. The significant reduction of soilage and dry matter yield by delaying seeding date was also previously noted by Choi and Lee(1985) and Kim (1986). It seemed that the increase of forage yields by early seeding was the result of the increase of plant density/m^2 by higher tillering(Ervio, 1979), higher dry weight per tiller(Fowler, 1982: Kwon & Kim, 1995), and greater accumulation of dry matter by higher LAI (leaf area index) and higher LAID(leaf area duration; leaf area index basis) (Kwon & Kim, 1995).

3) Feeding value

General nutritive components, TDN content and TDN yield depending on the seeding dates and varieties of triticale were listed in Table 4. The contents of nutritive components such as crude protein,

Table 4. Effect of seeding dates and varieties on the chemical compositions, TDN and TDN yield of triticale harvested at dough stage.

Seeding date	Variety	Crude protein	Crude fat	Crude fiber	Crude ash	NFE	TDN	TDN yield
		······	······	······	%	······	······	kg/10a
October 1	Prag 46/3	7.80	1.03	28.50	6.15	56.52	54.7	781
	Prego	8.60	1.17	26.64	6.15	57.44	55.9	644
	Presto	8.04	1.03	29.63	6.97	54.33	53.7	491
	Sinkihomil	8.13	1.22	28.97	5.41	56.27	54.2	957
	Mean	8.14	1.11	28.44	6.17	56.14	54.6	718
October 15	Prag 46/3	8.38	1.21	29.80	6.37	54.24	54.5	711
	Prego	8.00	1.26	26.67	5.65	58.42	56.3	584
	Presto	8.40	1.55	26.22	5.42	58.41	57.3	466
	Sinkihomil	8.41	1.11	26.05	6.45	57.98	55.7	843
	Mean	8.30	1.28	27.19	5.97	57.26	55.9	651
October 30	Prag 46/3	8.08	1.15	26.21	5.76	58.80	56.2	638
	Prego	8.28	0.87	28.76	6.36	55.73	54.3	523
	Presto	7.52	1.34	29.56	5.68	55.90	55.1	418
	Sinkihomil	8.26	0.95	29.72	5.94	55.13	54.4	828
	Mean	8.06	1.08	28.56	5.94	56.39	55.0	601
LSD(0.05)	Seeding date(A)	NS	NS	NS	NS	NS	NS	37.8
	Variety(B)	NS	NS	NS	NS	NS	NS	39.3
	Interactions(A × B)	NS	NS	NS	NS	NS	NS	NS

NS : non-significant.

crude fat, crude fiber and crude ash were not affected by seeding dates and varieties, and general nutritive components also fluctuated without an apparent pattern. TDN contents were not significantly different by seeding dates and varieties, but TDN yield was significantly reduced by delaying seeding and greatly varied with varieties. Sinkihomil showed the highest TDN yield at any of seeding dates; it produced 100~200kg/10a higher TDN yield than the following variety, Prag 46/3. TDN yield of Presto was lowest (400kg/10a) among the triticale varieties.

Hwang et al.(1985) and Park et al.(1990) found that soilage and dry matter yield were major factors to determine TDN yield. Similarly, the increase of TDN yield by early seeding was due to higher dry matter yield rather than the increase of nutritive components. Therefore, dry matter yield need to be considered as one of the primary factors for the improvement of TDN yield.

Macromineral contents of triticale by seeding dates and varieties are given in Table 5. Macromineral contents were not affected by seeding dates, and there was no difference among the varieties. However, K_2O contents were significantly different among varieties and this result was the same as the reports by Tingle and Dawley(1972). Prego was highest and Presto was lowest in K_2O content at all of seeding dates. Considering all of the above results, seeding dates do not appear to be a limiting factor for nutritive components when triticale is used as a whole crop

Table 5. Effect of seeding dates and varieties on the macromineral contents of triticale harvested at dough stage.

Seeding date	Variety	CaO	MgO	K_2O	P_2O_5
		………	……… %	………	………
October 1	Prag 46/3	0.14	0.11	2.57	0.52
	Prego	0.17	0.14	3.09	0.53
	Presto	0.14	0.11	2.44	0.50
	Sinkihomil	0.15	0.14	2.94	0.53
	Mean	0.15	0.12	2.79	0.52
October 15	Prag 46/3	0.15	0.12	2.54	0.47
	Prego	0.16	0.13	3.09	0.59
	Presto	0.14	0.12	2.30	0.44
	Sinkihomil	0.16	0.13	2.57	0.56
	Mean	0.15	0.13	2.76	0.52
October 30	Prag 46/3	0.17	0.14	2.77	0.48
	Prego	0.19	0.14	3.00	0.58
	Presto	0.15	0.12	2.35	0.48
	Sinkihomil	0.17	0.14	2.90	0.54
	Mean	0.17	0.13	2.63	0.52
LSD(0.05)	Seeding date(A)	NS	NS	NS	NS
	Variety(B)	NS	NS	0.18	NS
	Interactions(A × B)	NS	0.043	NS	NS

NS : non-significant.

silage by harvesting at the dough stage of development. On the other hand, extremely delayed seeding caused the decrease of TDN yield and forage yield. Finally, this reduction would result in the decrease of forage productivity and feeding value. Therefore, early seeding would be one of the most effective cultural method to improve forage productivity and quality as long as other required conditions are satisfied.

2. Effects of nitrogen fertilization rates on yield and nutritional value

1) Soilage and dry matter yield

Table 6 shows that the soilage and dry matter yield and percent dry matter of triticale varieties treated with different N fertilization rates. There was no significant difference in plant height. The reason was probably due to the fact that tested triticales from each treatment were harvested at the dough stage of development. Soilage yield significantly increased as the nitrogen fertilization rate increased up to a rate of 16kg of N/10a without further increase at 20kg of N/10a. However, dry matter yield significantly increased up to a rate of 20kg of N/10a and showed an 167kg of increase compared to 12kg of N/10a. Percent dry matter also showed a similar response to nitrogen fertilization rates like the dry matter yield. These results agreed with the studies on winter cereals such as rye, barley and wheat by Choi and Lee(1985), Morris and Gardner(1958), and Park et al.(1979).

Table 6. Effect of nitrogen fertilization rates and varieties on the plant height, forage fresh weight, forage dry weight and dry weight percentage of triticale harvested at dough satge.

Fertilization rate	Variety	Plant height	Forage fresh Wt.	Forage dry Wt.	Dry matter
kg/10a		cm	kg/10a	kg/10a	%
12	Prag 46/3	113.7	4,121	1,364	33.1
	Sinkihomil	128.4	4,585	1,589	34.7
	Mean	121.1[a] [1)]	4,353[b]	1,477[c]	33.9[c]
16	Prag 46/3	113.3	4,313	1,502	34.8
	Sinkihomil	129.0	4,623	1,648	35.7
	Mean	121.2[a]	4,468[a]	1,575[b]	35.3[b]
20	Prag 46/3	113.0	4,414	1,585	35.9
	Sinkihomil	130.0	4,660	1,702	36.5
	Mean	121.5[a]	4,537[a]	1,644[a]	36.2[a]

[1)] The same letters within the same columns are not significantly different at the 5% level by D.M.R.T.

2) Feeding value

Table 7 presents the contents of crude protein, crude fat, crude fiber, crude ash, NFE, TDN and TDN yield of the triticale varieties treated with different N fertilization rates. Crude protein content was 8.05% and 8.57% at fertilization rates of 12kg and 20kg N/10a, respectively. The contents of crude fat, crude ash and NFE also showed similar responses to N fertilization rates. However, crude fiber content decreased as N fertilization rate increased. There were significant increases in TDN yield as well as TDN content by increased fertilization rates. TDN yield showed 20% and 10.5% increase in Prag 46/3 and Sinkihomil, respectively, at 16kg N/10a compared to 12kg N/10a. It has been reported that the contents of crude protein and crude fat in barley and rye increased with increasing N fertilization rate(Choi & Lee, 1985), and crude fiber and crude ash contents of Japanese barnyard millet also increased as N fertilization rate increased(Lee, 1980). These results agreed with our findings. However, other nutritive components need to be further investigated since there was conflicting reports among researchers.

Table 7. Effect of nitrogen fertilization rates and varieties on the chemical compositions, TDN and TDN yield of triticale harvested at dough stage.

Fertilization rate	Variety	Crude protein	Crude fat	Crude fiber	Crude ash	NFE	TDN	TDN yield
kg/10a		………	………	………	%	………	………	kg/10a
12	Prag 46/3	7.95	1.06	29.00	5.43	56.56	55.23	753
	Sinkihomil	8.15	1.17	29.46	6.14	55.08	54.67	869
	Mean	8.05[c1)]	1.12[c]	29.23[a]	5.79[b]	55.82[c]	54.95[c]	811[c]
16	Prag 46/3	8.25	1.23	27.60	5.50	57.42	56.07	842
	Sinkihomil	8.25	1.26	27.21	6.18	56.47	55.20	910
	Mean	8.25[b]	1.25[b]	27.41[b]	5.84[b]	56.94[b]	55.63[b]	876[b]
20	Prag 46/3	8.75	1.43	25.47	5.88	58.48	57.10	905
	Sinkihomil	8.39	1.34	25.50	6.30	58.47	56.47	961
	Mean	8.57[a]	1.39[a]	25.48[c]	6.09[a]	58.47[a]	56.78[a]	933[a]

[1)] The same letters within the same columns are not significantly different at the 5% level by D.M.R.T.

Ⅳ. SUMMARY

This experiment was conducted to establish the cultural method of triticale(*Triticum Secalotriticum Saratoviense Meister*) as a whole crop silage by evaluating the effect of seeding date and nitrogen fertilization rate on forage yields and feeding value. Heading date, flowering date, and the dough stage of development came significantly earlier as triticale was seeded earlier. Soilage, dry matter yields and percent dry matter significantly varied with seeding dates and was increased by early seeding. There were no significant differences among different seeding dates in the contents of crude protein, crude fat, crude fiber, crude ash, NFE and TDN. However, TDN yield was significantly reduced by delayed seeding. Macro-mineral contents were not affected by seeding date. Soilage, dry matter yield, and percent dry matter significantly increased as nitrogen fertilization rate increased. The contents of crude protein, crude fat, crude ash, NFE, TDN and TDN yield also significantly increased. In contrast, crude fiber content of triticale decreased with increasing N fertilization rate.

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