Variablity of Protein Content in Rice Grown at Several Different Environments

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生育環境이 다른벼의 蛋白質 含量變異

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ABSTRACT

Protein content of Korean native and currently recommended varieties varied from 5.3% to 9.4%. Higher protein content was shown in Indicas than Japonicas and generally in the earlier varieties than in the latter ones. Additional application of nitrogen significantly increased the protein content, and varietal difference in this response was noticed. Delayed harvesting reduced protein content and denser planting induced higher protein content in the brown rice.

INTRODUCTION

Any increase in the protein content of rice would greatly enhance the nutritional status of Asians since the rice is staple food of many Asian countries. Interests to the varieties or lines having higher content of protein or more specifically having more essentia aminoacids are growing recently. Juliano[8] reported that the distribution of crude protein content was from 5 to 17% with the mode of 11% from the 7760 varieties analyzed in his screening test. Cultural environments such as planting date[4], locations[6], soil fertility, fertilizer application[9], and spacings[10] are also known to have influence on the protein content of rice kernel. Obscure results are reported on the relationships between the protein content and the cooking quality or eating preferences.

The purpose of this study was to obtain the informations on the varietal responses of protein content to the different cultural environments.

MATERIALS AND METHODS

Experiment I was planned to determine the varietal differences in protein content of rice grain with 22 currently recommended varieties and 11 of Korean native varieties. Ten out of these 22 recommended varieties, are the introduced ones from Japan. The seeds were sown on April 25 and seedlings were transplanted on May 30. The amount of N, P, K applied were 40, 50, and 60 kg/ha respectively as the basal application and 40 kg/ha of nitrogen as top dressing.

Total nitrogen in the grain was determined by the Micro Kjeldahl method and the results were multiplied by 5.95 to obtain the crude protein content. Each protein content was recalculated on 13% moisture base.

Experiment II was designed so as to determine the varietal responses in terms of protein content to the amount of nitrogen application. Four varietiese Jinheung and Kimmaze as Japonica type and T(N)1 and IR-8 as Indica type were sown on April 25 and transplanted on May 30. Three levels of nitrogen, 80, 120 and 160 kg/ha, were applied as 40% of the basal and the rest 60% as top dressing. The amount of P and K were 50 and 60 kg/ha, respectively same as in Experiment I. All the Nitrogen blocks were devided into 2 plots and one of them received organic matter and lime, that is, 3750 kg of rice straw, and 1000 kg of lime with 30 kg of boric acid crystal were applied besides nitrogen.

The method of analysis and calculations were same as in Experiment I.

Experiment III was designed to determine the effects of harvesting date on the protein content of rice. Single variety Kimmaze grown in the plots described in Experiment II was harvested on Oct. 10, Oct. 20, and Oct. 30 and analyzed for the protein. The other treatments and methods were the same as in Experiment II above described.

Experiment IV was planned to get the informations on the varietal responses in terms of protein content to the different planting densities. An Indica variety, T(N)1, and the Japonica varieties, Jinheung and Palkweng, were seeded on April 25 and transplanted on May 30, in the distances of 30 cm x 15 cm, 25cm x 15cm and 20cm x 15cm. 80:50: 60 kg/ha of N:P:K were applied as in Experiment I. The other treatments and methods were the same as in Experiment I above described.

RESULTS

Varietal differences in protein content

Protein content of total 33 varieties under study ranged from 5.3 to 9.4% with 6.58% in mean(Table 1). The group mean values of the Korean native, of the home bred current and of the introduced current were 6.82±0.174, 6.51±0.285 and 6.40 ± 0.29 respectively. Though there were no statistically significant differences among those group means, Korean native showed the highest and introduced showed the lowest.

Among those 22 currently recommended varieties the earlier variety had generally the higher protein content (Fig. 1).

Table 1. Protein content of brown rice of Korean native and currently recommended varieties which were bred in Korea and introduced from Japan

Korean native		Currently recommended			
		Bred in Korea		Introduced from Japan	
	%		%		%
Chungsando	7.7	Suwon #82	9.4	Shin #2	7.7
Daejangdo	7.3	Poongkwang	6.7	Fuzisaka #5	7.5
Daik #27	7.3	Jinheung	6.6	Shirogane	7.4
Nadoshin	7.2	Soosong	6.6	Kusabue	6.5
Jokjo	6.9	Kwanok	6.5	Norin #8	6.2
Daeryuk #3	6.8	Jaekun	6.4	Kinmnaze	6.1
Shin #97	6.8	Shinpoong	6.4	Ginbozoo	6.0
Phungyang	6.7	Palkum	6.3	Norin # 25	5.7
Soemorizizang	6.4	Palkweng	6.1	Norin # 29	5.6
Daekwondo	6.3	Paltal	6.0	Norin # 6	5.3
Jindo	5.6	Nongkwang	5.6		
		Hokwang	5.5		
$\bar{x}$	6.82		6.51		6.40
$S_{\bar{x}}$	0.174		0.285		0.290
Max.	7.7		9.4		7.7
Min.	5.6		5.5		5.3

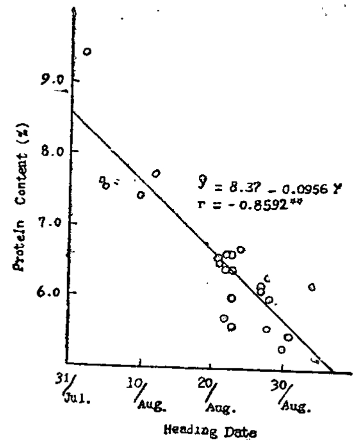

Fig. 1. Correlation between heading date and protein content of 22 currently recommended varieties of introduced varieties, of home bred varieties.

Varietal response to the amount of nitrogen application

Average protein content of each variety was 6.93% in Jinheung, 6.8% in Kimmaze, 10.13% in IR-8, and 9.95% in T(N)1 respectively. Average of four varieties at the nitrogen level of 80 N, 120 N, and 160 N were 7.74%, 8.66%, and 9.00% respectively. Slightly higher protein content was shown from the plots subjected to the additional application of organic matter with lime through all three nitrogen levels (Table 2).

Under the condition in which higher amount of nitrogen was applied, Japonica varieties indicated the reduced protein content by the application of organic matters with lime. On the contrary, Indica varieties showed the increased protein content by the application of organic matters with lime (Fig. 2).

Table 2. Protein content of brown rice of 4 varieties as affected by the organic matter and nitrogen applied.

Variety	80N		120 N		160N		Var. Mean
	No Org.	Org.	No Org.	Org.	No Org.	Org.	
Jinheung	6.5	6.4	6.8	7.0	7.8	7.1	6.93
Kimmaze	6.3	6.5	7.3	6.4	7.5	7.1	6.85
IR-8	8.3	10.4	9.9	11.0	10.1	11.1	10.13
T(N)1	9.0	8.5	10.3	10.6	10.2	11.1	9.95
N level mean	7.53	7.59	8.58	8.75	8.9	9.1	8.46

L.S.D. (for nitrogen leve) 5%=0.334 1%=0.486
(for variety) 5%=0.397 1%=0.470

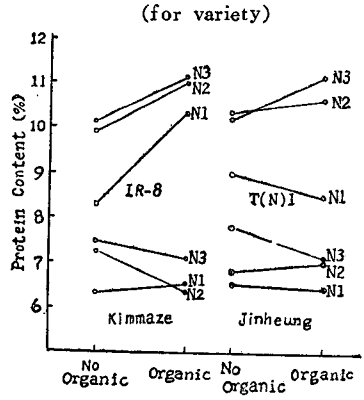

Fig. 2. Protein content of brown rice of 2 Indica varieties IR-8 and T(N)1 and 2 Japonica varieties Jinheung and Kimmaze as affected by the application of different levels of nitrogen and organic matter.
N1=80 kg/ha, N2=120 kg/ha, and N3= 160 kg/ha Nitrogen.

Effect of harvesting date of Kimmaze variety grown in the plots same as in Experiment II above described and harvested on Oct. 10, Oct. 20, and on Oct. 30 are shown in Table 3. The average protein contents throughout three nitrogen levels were 6.81%, 6.57% and 6.45% for the harvested on Oct. 10, Oct. 20 and on Oct. 30 respectively. That is, the protein content was reduced as the harvesting was delayed up to Oct. 30. The highest nitrogen application and organic matters with lime also caused higher protein content but at the 160 N level, the latest harvest caused slight increase in protein content (Fig. 3).

Effect of planting density on protein content

Generally closer spacings provided higher protein

Table 3. **Protein content of brown rice as affected by the harvesting date.**

Date Harvested	80N		120N		160 N		Date Mean
	No Org.	Org.	No Org.	Org.	No Org.	Org.	
Oct. 10	6.8	6.8	6.6	6.8	6.9	7.0	6.81
Oct. 20	6.7	6.3	6.5	6.6	6.5	6.8	6.57
Oct. 30	6.7	6.1	6.2	6.6	6.3	6.8	6.45
N level mean	6.73	6.40	6.43	6.67	6.57	6.87	6.61

L.S.D. for harvesting date 5%=0.286 1%=0.388
for N. level 5%=0.281 1%=0.409

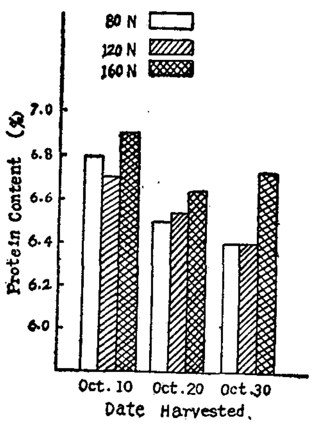

Fig. 3. Protein content of brown rice harvested on different date, which rice was grown under different levels of nitrogen. 80N =80 kg/ha, 120. N=120 kg/ha, and 160 N=160 kg/ha of nitrogen applied.

content in rice grain though there were no statistically significant differences within the range of densities tested here. The varietal differences were again significant (Table 4).

Table 4. Protein content of brown rice as affected by the planting spaces.

Variety	Spacing (cm) 30x15	25x15	20x15	Aver.	L.S.D (5%)
Jinheung	6.8	7.0	6.8	6.87	
Palkweng	7.5	7.4	7.7	7.53	
T(N)1	9.1	10.1	10.0	9.73	
Aver.	7.8	8.2	8.2	8.05	0.59

DISCUSSIONS

Varietal difference

Though the protein content of a variety varies as much as 6% in actual content depending upon the environment where it is grown [4,7] the varietal difference was more significant[8]). Those varieties listed in Table I, except a variety Suwon # 82, showed relatively low protein content, not over 8%. There were no marked varietal differences which were less than 2.4% in actual protein content. This probably was caused by the selection for tenderness, cohesiveness and for flavor among the breeding lines which were having relatively closer relationships. As Onate has reported[12]), in the selection of varieties for tenderness, cohesiveness and flavor it may accompany simultaneously the low protein content. Kito[10]) reported that the early varieties usually formed protein rich kernels than the late varieties. In this study also, the earlier variety generally showed the higher protein content as seen in Fig. 1. But further stuides are remained to be clarified, whether or not those early varieties showing high protein content would yield also the protein rich grains even under the conditions which their maturity were postponed until those late varieties would mature.

Indica varieties consistently showed higher protein content than the Japonica varieties under different nitrogen levels or different spacings. Similar results were reported previously [4]).

Effect of nitrogen and organic matters with lime

Great variability of protein content due to the environment was reported [5,6] as much as 6% actual protein content within a variety. Among the enviroments affecting plant growth, nitrogen application is prominent. With wheat, previous workers reported [1,2,11,14] that the additional application of nitrogen increased the protein content of wheat grain. For the rice, Kito[9] reported that the grains from the high nitrogen plot were richer in protein than from normally fertilized plot. In this study too, as shown in Table I and Figure 2, additional application of nitrogen markedly increased the protein content throughout the range of applied amount. The varietal response to the additional application of nitrogen in terms of increased protein content, were different depending upon the variety. The Indicas showed greater responses than the Japonicas tested here.

Organic matter applied together with lime and boric acid affected differently to the Indica and the Japonica, especially when the high level of nitrogen was applied. That is, Japonica varieties showed the decreased protein content by the additional application of organic matter with lime while the Indicas, increased. Schrenk [13] reported that the Calcium application caused decrease in protein content of wheat grain while it increased the Calcium content in the grain. The clarification of those contradictory phenomenon will be remained to be worked out in further studies.

Effect of harvesting date

Bressani[3] reported the constant decrease in nitrogen content of maize grain during maturation. Similar results with sorghum was reported by Webster [15]. IRRI reported that the rice planted in November and grown during the shorter day length period had higher protein content in brown rice than planted in December and grown during the longer day-length period. Kimmaze variety examined in this experiment gradually reduced protein content in the grain at the 80 N and 120 N levels along the maturation. At the highest nitrogen level, for the variety, maturation was delayed, and by the time Oct. 30, the reduction of nitrogen in the grain was possibly hampered by low temperature.

Effect of planting density

Kito[10] reported that the dense planting induced protein rich kernels. Yamazaki [26] also reported similar results with wheat. The result obtained here evidently shows the trend that the more dense planting the higher protein content is induced, though the individual variety was not always consistent with the trend. Extended further studies may bring better understanding for the scope of variability in protein content along the varied densities.

摘　　要

쌀 蛋白質 含量의 品種과 環境에 따른 變異를 알고자 韓國在來品種 11, 韓國에서 育成된 현장려품종 12 및 日本에서 導入된 현장려품종 10, 合計 33 品種을 普通栽培하고, 한편 Indica 2品種과 Japonica 2 品種을 有機物과 窒素施用量을 달리하여 栽培하고, 이들 현미의 窒素를分析하여 이것을 蛋白質 含量으로 換算하여 검토한 結果를 要約하면 다음과 같다,

1. 11개 재래품종군의 단백질 함량은 평균 6.82%, 국내에서 육성된 장려품종군의 평균은 6.51%, 도입된 장려 품종군의 평균은 6.40%로 統計的으로 有意하지 않았으나 在來 品種群이 높은 편이었다.
2. 대체로 早生種일수록 蛋白質 含量이 높은 傾向이었으며, 供試된 Indica 品種들이 蛋白質含量은 현저하게 높았다.
3. 窒素肥料의 增施는 蛋白質 含量을 현저하게 증가시켰지만 有機物과 石灰의 施用은 거의 影響이 없었다.
4. 收穫期가 늦어질수록 蛋白質 含量은 減少하는 傾向이 있었다.
5. 栽植密度가 높아짐에 따라 蛋白質含量이 높아지는 경향이 있었으나 本試驗의 密度範圍에서는 各品種들은 一定한 傾向을 보이지 않았다

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