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EFFECT OF VARIETY AND GROWING SEASON ON MAIZE GRAIN YIELD AND QUALITY IN SOUTHERN CHINA

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ABSTRACT

Hasan S, Qinghong C, Qiyuan T, Kun W, Ahmed S (2014) Effect of variety and growing season on maize grain yield and quality in Southern China. *Int. J. Sustain. Crop Prod.* 9(2), 47-52.

The performances of six important maize varieties were studied in two growing seasons with the aim of achieving maize grain yield and quality improvement in southern China during 2011. The varieties were; Early-maturing varieties (Yinong 103 & Zhengdan 958), Mid-maturing varieties (Denghai 9 & Denghai 11), Late-maturing varieties (Zhengda. 999 & Chao shi 1). The experimental design was Randomized Complete Block Design (RCBD), with six (6) treatments and three (3) replications. In spring Yinong 103 and Zhengdan 958 took 114 days to reach maturity while all the rest matured ten (10) days later at 124 days. In autumn Yinong 103 and Zhengdan 958 took 105 days to reach maturity while all the rest matured earlier at 95 days. Maize grain yields were significantly different *($P < 0.05$)* in both seasons among the varieties studied. In spring Denghai 11 gave the highest grain yield of 10.4 tons per hectare followed by Chao shi 1 (10.1 t ha^{-1}) Denghai 9 (9.8 t ha^{-1}), Zhengdan 958 (9.1 t ha^{-1}), Zhengda 999 (8.5 t ha^{-1}) and Yinong 103 (6.8 t ha^{-1}) respectively. In autumn Denghai 9 gave the highest grain yield of 6.8 t ha^{-1} followed by Denghai 11 (6.2 t ha^{-1}), Chao shi 1 (6.2 t ha^{-1}), Zhengda. 999 (5.9 t ha^{-1}), Zhengdan 958 (5.7 t ha^{-1}) and Yinong 103 (4.9 t ha^{-1}), respectively. There were significant differences ($P < 0.05$) in starch content among the six varieties in spring but not in autumn. The protein content of maize grain among the varieties in both seasons was also significantly different ($P < 0.05$). The fiber content was also significantly different ($P < 0.05$) in both season but lower in spring than in autumn. There was significant difference ($P < 0.05$) in both seasons among the maize varieties in all the amino acids studied and leucine levels were the highest of the essential amino acids compared to others.

***Key words**: maize, grain yield, grain quality, variety, growing season*

INTRODUCTION

In China, maize (*Zea mays* L.) has become the second largest crop in terms of total production, growing area, and plays a key role in the agricultural structure of the country (Yu *et al.* 2007). Maize has been grown in China for centuries (Meng *et al.* 2006) and is China's second largest crop after rice. Maize is widely cultivated throughout the world with broad applications, including human and animal food, biofuel, chemicals and medicines. With the rapid and continuous population growth and the increasing land requirements for urbanization and industrialization, ensuring food security with the limited supply of land resources has always been the focus of Chinese government and the people (Ramankutty *et al*. 2002; Zhang *et al*. 2008).

Maize Varieties and Grain Yield

In general, corn varieties with high yield, fitness for being planted in high density, grains drying quickly, etc., are welcomed by peasant farmers in China. The search has been for maize hybrids varieties adapted to specific local environments with high yield potential as a means of minimizing the wide national disparity in maize yields across the various regions. Maize is cultivated in every province in China but the wide range of climatic and geographical variation in the country, in addition to other factors affecting production and consumption patterns has resulted in significant differences in maize cropping patterns, practices and yield in China. According to Setiyono *et al*. (2010), China's national average maize grain yield from 2005 to 2009 is 5.3 tons per hectare. It became very popular soon after it was put on the market and replaced Denghai No. 11 only in a few years, taking up 25% of the market share across the country. The planting area of Zhengdan 958 in 2009 was 4.54 million hectare making it to become the biggest maize species in China (2005-2008 www.reseaerchinchina.com; www.enchemicals.com-Seed China news).

Zhengdan 958 has outstanding grain yields. It can generate relatively stable yield under different growing conditions and has good resistance against diseases. This variety can be planted in high density and the ideal planting density is 60,000 to 75,000 plants per ha. However, the variety also has some drawbacks. The grain of this variety dries slowly before harvest, stalks are easy to lodge and in some regions, ear rot disease, sheath blight disease and brown spot disease has been reported. Zhengdan 958 is still one of the best corn varieties in China. It is estimated that this variety will continue to be the major variety planted in China in the coming years.

Maize Varieties and Grain Quality

The importance of maize grains to the nutrition of millions of people around the world is widely recognized. The major chemical component of the maize grain is starch, which provides up to 72 to 73 percent of the grain weight and is subject to genetic influence. That means the quantity of starch can be modified by breeding as described in reviews by Boyer and Shannon (1983) and Shannon and Garwood (1984). After carbohydrates, proteins and fats, dietary fibre is the chemical component found in the greatest amounts. The seed-coat is high in crude fibre (Burge and Duensing, 1989).

The level and type of amino acids found in maize grain, especially essential amino acids, is an important indicator of its nutritional quality (Liu 2003). Varietal differences in nutrient composition within the hybrids of maize have been reported by several investigators respectively.

The amino acids regarded as essential for humans are phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine, lysine, and histidine (Young 1994). Generally, humans should take in 51 mg lysine per gram of protein (Zhai 1991).

The reasons for the low quality of maize proteins have been extensively studied by numerous investigators. Among the first were Mitchell and Smuts (1932) who obtained a definite improvement in human growth when 8 percent maize protein diets were supplemented with 0.25 percent lysine. These results have been confirmed over the years by several authors (e.g. Howe, Hogan *et al*. (1955) reported that tryptophan rather than lysine is the first limiting amino acid in maize. Researchers generally accept, however, that the simultaneous addition of both lysine and tryptophan improves the protein quality of maize significantly. The limiting amino acid after lysine and tryptophan is isoleucine (Harper, which results from an excess of leucine which interferes with the absorption and utilization of isoleucine (Harper; Benton *et al.* 1956).

The levels of dietary protein, then, affect the response observed upon amino acid supplementation with lysine, tryptophan, isoleucine and threonine. In this investigative study of six important maize varieties in two growing seasons, the aim is to evaluate their performance against the national interest of maize grain yield and quality improvement in southern China. It is important to research and look out for ways of improving high yielding maize varieties for future use.

MATERIALS AND METHODS

Field Site Description

The experiment was conducted at Dongkou (27^o 07 N, 110^o 37S) in the Hunan Province of Southern China between March, 2011 to November 2011. The climate of this region is Sub-tropical monsoon with an annual average rainfall of 1,482.5 mm and Annual average temperature of 16.6^{0}C. The sunshine duration is 1569.2 h. The soil at the experiment site is sandy, yellow in color and sticky (Genetic soil classification of China, GSCC) with pH (H_2O) of 5.5. The soil organic matter content was 46.2 mg per kg; alkali hydrolysable N content was 58.2 mg per kg, available P (0.5 mol l^{-1} 110 Nutr Cycl Agroecosyst (2009) 85:109–121 $NaHCO_3$) was 30 mg/ kg and exchangeable K (1 mol l^{-1} NH_4CH3COO) was 50 mg per kg. In spring, N, were applied at the rate of 112, 103,103 and 51.6 kg/ha at sowing time, V_6 (jointing stage), V_{12} and V_T (flowering time) stage respectively. In autumn, N_2 were applied at the rate of 112, 54, 72 and 54 kg ha^{-1} at sowing time, V_6 (jointing stage), V_{12} and V_T stage respectively. In both season, phosphorus were applied at the rate of 112 kg ha^{-1} at sowing (basal) time only. In spring, potassium were applied at the rate of 112 and 142 kg ha^{-1} at sowing time and V_6 (jointing stage) respectively. In autumn, potassium were applied at the rate of 112 and 82.5 kg ha^{-1} at sowing time and V_6 (jointing stage) respectively. The unit plot size was 7m x 4.8m. Inter row distance was 40 cm and intra row distance was 22.2cm. Two seeds was sown in a hill and later thinned to one plant per hill.

Experimental Design and Management

The experimental design was Randomized Complete Block Design (RCBD), with six (6) treatments and three (3) replications. The six treatments (varieties) were; Early-maturing varieties, Yinong 103 & Zhengdan 958), Mid-maturing varieties (Denghai 9 & Denghai 11), Late-maturing varieties (Zhengda.999 & Chao shi 1). Seeds were collected from the Chinese Academy of Agricultural Sciences. In spring, the seeds were sown on 27th March 2011 and harvested on 21-31 July 2011 July 2011. In autumn, the seeds were sown on 21-31 July, 2011 and harvested on 25-28 October - 4 November, 2011.

In spring maize, PKN (Chinese name: jukangnaiheji) was sprayed at 3-leaf stage to harden seedlings against low temperature at seedling stage. Ethephon-cycocel (EC) was sprayed at 6-leaf stage to resist lodging. PKN was again sprayed at 12-leaf stage to harden plants against high temperature at grain filling stage. In autumn maize, chlorocholine chloride (CCC) was sprayed at 3-leaf stage to harden seedlings against high temperatures. PKN was sprayed again at V_6 stage to avoid low temperature during grain filling. All emulsifiable concentrate (EC) of these plant growth regulators were sprayed at the ratio of one part of water to one part of the EC. In spring, plastic film mulch was spread over the plot after seed sowing. During emergence the plastic film mulch was cut-through around the hills about 3-4 cm wide to allow the seedling to emerge and grow out. Keep the plastic film mulch up to V_6 stage and after V_6 stage we removed the plastic film mulch from the whole plot. In autumn, maize straw cut into 7 cm pieces was used as mulch instead of plastic film mulch and during emergence the hills were freed from the straw mulch.

Dursbern (chloropieryphos), insecticide was sprayed at a rate of 2 ml per litre of water near the base of the plant to protect them from cutworms. First weeding was done at V_6 stage before fertilization. Second weeding was done at V_9 stage. In autumn, the plots were irrigated after sowing but in spring there was no need for irrigation during the entire growth period. The crops were harvested when the breast line disappeared and the black layer of grain in cobs developed.

Sampling and Measurement

Total grain yield of individual plants of each plot was taken as yield per plot and extrapolated to yield per hectare. Biochemical analysis for crude protein, starch, fibre, fat and amino acid were performed at Analyzer laboratory in Hunan Agricultural University using the Association of Official Analytical Chemists method (AOAC 1990). Analysis of Variance and Co-variance for all the characters and comparison of treatment means were made following Duncan's Multiple Range Text with the aid of the *Statistix 9.0* 1985-2008 Analytical Software.

RESULTS AND DISCUSSION

Days to Maturity and Yield

The six varieties studied in spring reached maturity in 114 to 124 days period while in autumn it took them 95 to 105 days to reach maturity. In spring Yinong 103 and Zhengdan 958 took 114 days to reach maturity while all the rest matured ten (10) days later at 124 days period. However in autumn Yinong 103 and Zhengdan 958 took 105 days to reach maturity while all the rest matured in 95 days. In this way Yinong 103 and Zhengdan 958 matured nine days earlier in autumn than in spring. All the other varieties matured 29 days earlier in autumn than in spring (Table 1).

Table 1. Effects of maize varieties and growing season on yield and days to maturity

Maize Varieties	Spring		Autumn	
	Days to Maturity	Maize Yield ($t\ ha^{-1}$)	Days to Maturity	Maize Yield ($t\ ha^{-1}$)
Yinong 103	114	6.7d	105	4.9c
Zhengdan 958	114	9.0bc	105	5.7bc
Denghai 9	124	9.8ab	95	6.8a
Denghai 11	124	10.4a	95	6.2ab
Zhengda.999	124	8.5c	95	5.9b
Chao shi 1	124	10.1ab	95	6.2ab

Within each column, means followed by the same small letters are not significantly different by the LSD test at P<0.05

Although Yinong 103 and Zhengdan 958 had matured early (114 days) in spring compared to the rest, it still matured much earlier (105 days) in autumn than in spring. Again, although Denghai 9, Denghai 11, Zhengda 999 and Chao shi 1 matured in 124 days in spring they matured much earlier in autumn in only 95 days. According to the IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002, existing maize varieties in Southwest China take 120 to 150 days to reach maturity in spring maize growing cycle. This indicates that these varieties with a spring growing cycle of 114 to 124 days are exhibiting early maturing characters. This trait is more pronounce in autumn growing cycle as they took a shorter time of 95 to 105 days to reach maturity.

There were significant differences in grain yields ($P< 0.05$) in both seasons among the maize varieties studied. The delay in number of days taken to reach maturity in spring compared to autumn by the varieties resulted in a generally higher maize grain yields in spring compared to autumn maize grain yields. The maize grain yield in spring ranged from 6.718 to 10.1 tons ha^{-1}while that for autumn was 4.88 to 6.826 tons per hectare. In spring Denghai 11 gave the highest maize grain yield of 10.4 tons ha^{-1} followed by Chao shi 1 (10.1 tons ha^{-1}), Denghai 9 (9.8 tons ha^{-1}), Zhengdan 958 (9.1 tons ha^{-1}), Zhengda 999 (8.5 tons ha^{-1}) and Yinong 103 (6.8 tons ha^{-1}), respectively (Table 1).

In autumn, Denghai 9 gave the highest grain yield of 6.8 tons ha^{-1} followed by Denghai 11 (6.2 tons ha^{-1}), Chao shi 1 (6.2 tons ha^{-1}), Zhengda 999 (5.9 t ha^{-1}), Zhengdan 958 (5.7 tons ha^{-1}) and Yinong 103 (4.9 tons ha^{-1}), respectively. The decline in yield among varieties from spring to autumn growing seasons ranged from 1.838 tons per hectare for Yinong 103 to 4.117 tons ha^{-1} for Denghai 11 which represents 27.36% to 39.87%. Compared to the Chinese national average grain yield of 5.3 tons per hectare it implies that in spring the maize grain yield performance of Denghai 11 was 194.83% better followed by Chao shi 1 (189%), Denghai 9 (184.25%), Zhengdan 958 (170.34%), Zhengda 999 (160.09%) and Yinong 103 (126.75%), respectively. In autumn however the grain yield performance compared to the Chinese national average shows that Denghai 9 was 128.79% better followed by Denghai 11 (117.15%), Chao shi 1 (116.23%), Zhengda 999 (111.32%), Zhengdan 958 (107%) and Yinong 103 (92.08%), respectively.

The grain yield performance of these varieties compares favorably with the American national grain average of 6.3 tons per hectare which stands out as the highest in the world .Therefore these varieties have the potential to improve the Chinese national average grain yield and can also become some of the best varieties in the world in terms of maize grain yield. They all performed well above the world maize grain yield average of 4.5tons per hectare (from 1997 to 2006). In spring the best three varieties were Denghai 11 (10.4 t ha^{-1}) followed by Chao shi 1 (10.1 t ha^{-1}) and Denghai 9 (9.8 tons ha^{-1}). Growing these maize varieties in spring in Southern China is a more profitable venture than autumn production. Although Zhengdan 958 is becoming more and more popular among Chinese farmers it does not necessarily have the best yield in this study. This growing popularity may be due to other growing qualities such as thin cob (internal) and big kernel. From this study it is clear that more research should be done in order to make a scientifically informed decision over the need to replace Denghai 11 with Zhengdan 958. Perhaps some of the good qualities in Zhengdan 958 can be infused into Denghai 11 through breeding programs in order to still take advantage of the high yielding potential of Denghai 11 instead of replacing it completely with Zhengdan 958.

Grain Quality Analysis

a) Starch, Protein, Fat and Fiber content

Table 2. Effects of Maize Varieties and Growing season on Starch, Crude Protein, Fat and Fiber Content

Maize Varieties	Spring				Autumn			
	Starch %	Protein %	Fat %	Fiber %	Starch	Protein %	Fat %	Fiber %
Yinong 103	74.667a	8.974a	4.578bc	1.337d	66.821a	8.473ab	4.118a	2.235c
Zhengdan 958	72.532ab	8.447ab	4.336c	2.271a	72.707a	8.245ab	4.259a	2.137c
Denghai 9	73.489ab	7.606c	5.185ab	1.671bc	69.902a	8.180ab	4.820a	2.769ab
Denghai 11	69.484b	7.791bc	5.004abc	1.403cd	69.379a	8.852ab	4.159a	3.135a
Zhengda.999	62.083c	8.169abc	5.817a	1.969ab	71.764a	7.950b	4.254a	2.502bc
Chao shi 1	74.833a	7.843bc	5.054abc	2.003a	68.788a	8.908a	4.527a	2.801ab

Within each column, means followed by the same small letters are not significantly different by the LSD test at P< 0.05

There were significant differences (P<0.05) in starch content among the six varieties in spring but not in autumn. During the spring growing season Chao shi 1 gave the highest starch content of 74.833% while Zhengda 999 had the lowest starch content of 62.083% (Table 2). The starch content of Yinong 103, Zhengdan 958, Denghai 9 and Chao shi 1 were high and similar to values reported by Boyer and Shannon (1983) and Shannon and Garwood (1984). There were significant differences (*P< 0.05*) in protein content of maize grain among the varieties in both seasons. In spring Yinong 103 had the highest protein content of 8.974% with Denghai 9 showing the lowest protein content of 7.606% (Table 4). In autumn growing season however Denghai 11 had the highest protein content of 8.852% while Zhengda 999 had the lowest (7.950%). The range of protein content was similar to that observed by other authors (FAO 1992).

Differences in fat content among varieties during the spring growing season show significant difference (*P< 0.05*) but there were no significant differences among them in the autumn growing season (Table 4). Zhengda 999 gave the highest fat content of 5.817% while Zhengdan 958 (4.336%) had the lowest. The varieties showed significant differences (*P<0.05*) in crude fiber content in both seasons but the fiber content in spring growing season was lower than that in autumn (Table 2). In spring Zhengda 999 (5.817%) had the highest fiber content while Zhengdan 958 (4.336%) had the lowest. In autumn however Denghai 11 (3.135%) had the highest fiber content with Zhengdan 958 (2.137%) showing the lowest fiber content. These results show that the starch, protein, fat and fiber content of these maize varieties are similar to that reported by Angel *et al.* (1982) and Duensing (1989) and FAO (1992).

b) Amino Acids

Among all the amino acids studied, glutamic acid content was the highest compared to other amino acids within the maize varieties but it is not an essential amino acid. The highest essential amino acid among the varieties is leucine and it was significantly different (*P<0.05*) among the maize varieties in both seasons. In spring Denghai 11 gave the highest (0.878%) leucine content while Chao 1 had the lowest (0.744%). Leucine content in autumn also was highest for Denghai 11(0.909%) but lowest for Zengdan 958(0.691%). Yinong 103 (0.333%) gave the highest lysine content in spring while Zhengda 999 (0.292%) gave the lowest. In autumn Zhengda 999 (0.285 %) gave the highest lysine content while Chao shi 1 (0.229%) gave the lowest. The threonine content in spring season growing cycle was highest in Zhengda 958 (0.307%) but lowest for Zhengdan 999 (0.277%). In autumn Danghai 11 (0.29%) had the highest threonine content, with Zhengda 958 (0.256%) having lowest (Table 3a to 3d).

Table 3a. Effects of maize varieties and growing season on amino acid content

Maize Varieties	Spring				Autumn			
	Asparagine	Threonine	Serine	Glutamic Acid	Asparagine	Threonine	Serine	Glutamic Acid
Yinong 103	0.555b	0.293b	0.363b	1.320d	0.484c	0.263b	0.312c	1.173d
Zhengdan 958	0.551b	0.307a	0.383a	1.469a	0.474c	0.256c	0.294d	1.157e
Denghai 9	0.5495b	0.298b	0.349b	1.368c	0.504b	0.264b	0.331b	1.332b
Denghai 11	0.606a	0.296b	0.359b	1.435b	0.614a	0.290a	0.362a	1.440a
Zhengda.999	0.497c	0.277c	0.318c	1.306e	0.5085b	0.286a	0.355a	1.328b
Chao shi 1	0.550b	0.282c	0.327c	1.299e	0.462d	0.260bc	0.324b	1.268c

Within each column, means followed by the same small letters are not significantly different by the LSD test at P < 0.05

Table 3b. Effects of maize varieties and growing season on amino acid content

Maize Varieties	Spring				Autumn			
	Proline	Glysine	Alanine	Valine	Proline	Glysine	Alanine	Valine
Yinong 103	0.574f	0.366b	0.571cd	0.371cd	0.561c	0.308c	0.483e	0.317d
Zhengdan 958	0.647a	0.363b	0.623a	0.396a	0.555c	0.292d	0.477e	0.318d
Denghai 9	0.609c	0.372a	0.595b	0.384b	0.578b	0.299d	0.547c	0.327c
Denghai 11	0.625b	0.371a	0.626a	0.401a	0.607a	0.328b	0.607a	0.375a
Zhengda.999	0.595e	0.318c	0.578c	0.368d	0.584b	0.339a	0.573b	0.351b
Chao shi 1	0.602d	0.362b	0.566d	0.375c	0.613a	0.293d	0.515d	0.321cd

Within each column, means followed by the same small letters are not significantly different by the LSD test at P < 0.05

Table 3c. Effects of maize varieties and growing season on amino acid content

Maize Varieties	Spring				Autumn			
	Methionine	Isoleucine	Leucine	Pheny-alanine	Methionine	Isoleucine	Leucine	Pheny-alanine
Yinong 103	0.118a	0.232d	0.767d	0.334bc	0.087ab	0.200e	0.709d	0.279e
Zhengdan 958	0.099c	0.247b	0.875a	0.364a	0.074d	0.196e	0.691e	0.275e
Denghai 9	0.104b	0.239c	0.817b	0.341b	0.091a	0.217c	0.819b	0.312c
Denghai 11	0.095d	0.251a	0.878a	0.355a	0.081c	0.246a	0.909a	0.349a
Zhengda.999	0.091e	0.230d	0.803c	0.324c	0.084bc	0.225a	0.798c	0.329b
Chao shi 1	0.104b	0.224e	0.744e	0.309d	0.083bc	0.205d	0.786c	0.293d

Within each column, means followed by the same small letters are not significantly different by the LSD test at P < 0.05

Table 3d. Effects of maize varieties and growing season on amino acid content NH3

Maize Varieties	Spring				Autumn			
	Lysine	Histidine	Arginine	NH3	Lysine	Histidine	Arginine	NH_3
Yinong 103	0.333a	0.217b	0.399b	0.138d	0.250c	0.230a	0.286c	0.167c
Zhengdan 958	0.317c	0.226ab	0.390c	0.161a	0.248c	0.210d	0.278d	0.136f
Denghai 9	0.328ab	0.225ab	0.393bc	0.149bc	0.231d	0.215cd	0.277d	0.175b
Denghai 11	0.316c	0.225ab	0.379d	0.151b	0.266b	0.223b	0.318b	0.183a
Zhengda.999	0.292d	0.208c	0.351e	0.143cd	0.285a	0.220bc	0.344a	0.150e
Chao shi 1	0.323bc	0.228a	0.417a	0.139d	0.229d	0.213d	0.268e	0.156d

Within each column, means followed by the same small letters are not significantly different by the LSD test at P < 0.05

Common maize is high in leucine content but deficient in lysine, tryptophan and threonine. Generally, humans should take in 51 mg lysine per gram of protein (Zhai 1991). This requires the lysine content be more than 0.5% in maize grain. Livestock and poultry feed must be 0.6–0.8% lysine (Tian *at al.* 2004).

The luecine, threonine and lysine contents were similar to that observed by Angel and Sotelo (1982) and Yang *at al.* (2009). Lysine is the most limiting essential amino acid in maize and its content among the varieties ranged from 0.292% (Zhengda 999) to 0.333% (Yinong 103) in spring and in autumn, it ranged from 0.229% (Chao shi 1) to 0.285% (Zhengda 999). A number of studies in maize have shown that it is possible to increase the lysine content to sufficiently high levels to meet the requirements for human and animal feeding, with no need for addition of supplemental lysine. The present results show that there is still more work to be done to improve the lysine levels of these important maize varieties to the recommended levels of 0.5% or more required for human and animal nutrition (Zhai 1991; Tian *at al.* 2004).

CONCLUSION

The performances of six important maize varieties were studed in two growing seasons in the Hunan Province of Southern China in the Hunan Agriculture University. The varieties showed early and mid maturing characters with none of them being late maturing. Maize grain yields were significantly different ($P<0.05$) in both seasons and the yields were higher in spring than in autumn. The results show that these varieties have high grain yielding qualities and have the potential to improve the Chinese national average maize grain yields and can be among the best maize varieties in the world. There were significant differences ($P<0.05$) in starch content among the six varieties in spring but not in autumn. It may be due to high temperature. There were significant differences ($P<0.05$) in protein content of maize grain among the varieties in both seasons. Differences in fat content among varieties during the spring growing season show significant difference ($P<0.05$) but not in autumn growing season. It may be due to high temperature. The varieties showed a lower fiber content in spring growing season than in autumn. Among all the amino acids studied, leucine levels were the highest of the essential amino acids compared to others in both seasons and they were significantly different among the maize varieties. Lysine is the most limiting essential amino acid in maize and its content among the varieties ranged from 0.292% (Zhengda 999) to 0.333% (Yinong 103). The present results show that the maize grain yield, starch, protein, fat and fiber contents of the varieties are very good. However, there is still more work to be done to improve the lysine levels of these important varieties to the recommended level 0.5% or more required for human and animal nutrition. This will give these varieties competitive edge above others not only in China but in the world at large.

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