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TWC/33/27 Rev.
ORIGINAL: English
DATE: July 13, 2015

INTERNATIONAL UNION FOR THE PROTECTION OF NEW VARIETIES OF PLANTS

Geneva

TECHNICAL WORKING PARTY ON AUTOMATION AND COMPUTER PROGRAMS

Thirty-Third Session
Natal, Brazil, June 30 to July 3, 2015

ANALYSIS OF VARIANCE FOR "VARIETY ×LOCATION" (ENVIRONMENT) INTERACTION OF QN CHARACTERISTICS

Document prepared by an expert from China

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1. The Technical Working Party on Automation and Computer Programs (TWC), at its thirty-second session, held in Helsinki, Finland, from June 3 to 6, agreed to request experts from China to present the analysis of variance for the interaction "variety x location" (environment) of the QN characteristics considered in the study using the statistical module of the new software "DUSTC", developed by China, for presentation during the thirty-third session of the TWC (see document TWC/32/28 "Report", paragraph 81).

2. The Annex to this document contains a copy of a presentation on "analysis of variance for "variety ×location" (environment) interaction of QN characteristics" that was made at the thirty-third session of the TWC.

[Annex follows]

ANNEX

UPOV TWC
Thirty-Third Session
Natal, Brazil, June 30 to July 3, 2015

Analysis of variance for "variety × location" (environment) interaction of QN characteristics

Experts from China

Contents

Analysis of variance
-Zhengdan 958 in different locations over 2 years

- **Variety:** Zhengdan 958 (hybrids, *Zea mays* L.);
- **7 locations:** Harbin(HEB), Gongzhuling(GZL), Jinan(JN), Nanjing(NJ), Yangling(YL), Chengdu(CD),Urumchi(URMQ),;
- **Years:** 2012 and 2013.
- **Measurement:** on the basis of 13 QNs used in national Maize DUS testing guideline.

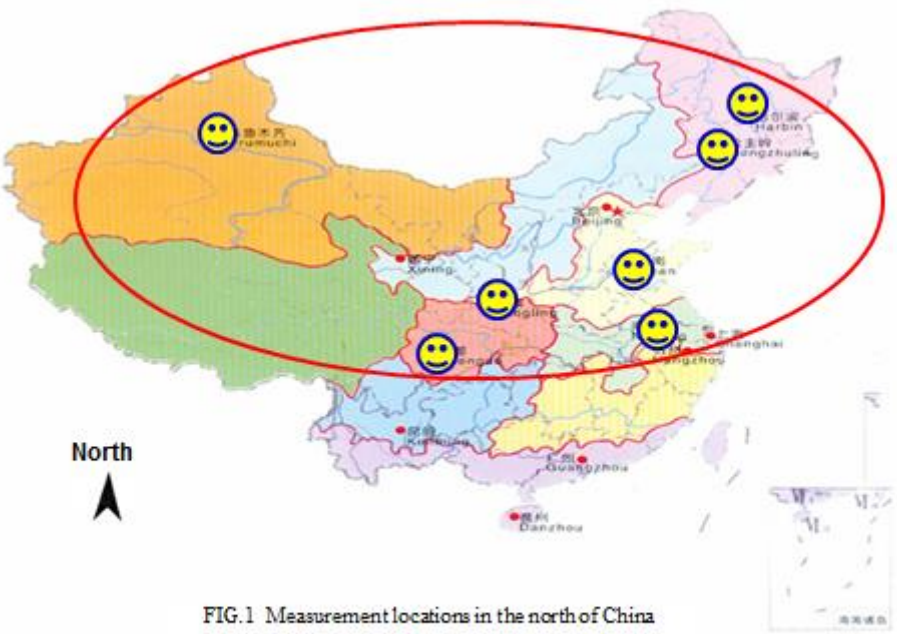


FIG.1 Measurement locations in the north of China

Analysis of variance
-Zhengdan 958 in different locations over 2 years

◆ Location

Table 1 Geographical factors of 7 DUS testing locations which Zhengdan 958 was measured in years 2012-2013

Trial location	Abbr. code	Longitude	Latitude	Altitude(m)
Harbin, Heilongjiang	HEB	128° 32′	45° 45′	127
Gongzhuling, Jilin	GZL	124° 42′	43° 25′	175
Jinan, Shandong	JN	117° 04′	36° 42′	27
Nanjing, Jiangsu	NJ	118° 24′	32° 20′	26.5
Yanglin, Shaanxi	YL	108° 04′	34° 15′	454
Chengdu, Sichuan	CD	104° 06′	30° 36′	513
Urumqi, Xinjiang	URMQ	87° 34′	43° 47′	947

Analysis of variance
-Zhengdan 958 in different locations over 2 years

◆ Characteristic

Table 2 Measured characteristics and observed method

No.	Characteristics	Abbr. code	Observed method
1	Time of anthesis	*Toa*	MG
2	Time of silk emergence	*Tos*	MG
3	Tassle：length of main axis above lowest lateral branch	*Loi*	MS
4	Tassle：length of main axis above highest lateral branch	*Loh*	MS
5	Tassel: number of primary lateral branches	*Nop*	MS
6	tassel：length of lateral branch	*Lob*	MS
7	Leaf：width of blade	*Wob*	MS
8	Plant：height of insertion of peduncle	*Php*	MS
9	Plant：length	*Ple*	MS
10	Plant: ratio height of insertion of peduncle of upper ear to plant length	*Rhl*	MS
11	Ear：length	*Ele*	MS
12	Ear：diameter	*Edi*	MS
13	Ear：number of rows of grain	*Enr*	MS

Analysis of variance
-Zhengdan 958 in different locations over 2 years

◆ Result of analysis of variance

Table 3 The analysis of variance of 13 characteristics measured two years in 7 different locations

Experimental factors		Tos	Tas	Lol	Lok	Nep	Lob	Wob	Pkp	Ple	Rkl	Ele	Edi	Ewr
Year	2012	63.56 a	64.05 a	35.04 a	24.81 a	14.26 a	20.57 a	10.53 a	113.40 a	253.03 a	0.45 a	18.28 a	5.11 a	15.70 a
	2013	62.92 a	63.46 a	34.05 a	24.31 a	14.25 a	19.37 a	10.34 a	104.03 a	245.68 a	0.42 b	18.09 a	5.08 a	15.25 a
Location	NJ	65.38 ab	64.63 abc	32.48 a	23.96 a	11.88 bc	17.84 bc	10.62 ab	81.09 b	202.81 cd	0.40 b	15.77 c	4.80 b	15.09 b
	JN	55.77 c	56.50 c	33.64 a	25.23 a	11.76 bc	18.70 bc	9.47 d	86.44 b	220.10 bcd	0.39 b	17.62 abc	4.93 b	14.90 b
	YL	62.22 bc	62.58 bc	34.67 a	24.65 a	10.32 c	19.94 abc	9.80 cd	100.21 b	236.76 bc	0.43 ab	17.78 abc	4.85 b	14.97 b
	URMQ	61.50 bc	64.50 abc	35.80 a	23.83 a	17.80 a	22.57 a	10.22bc	124.13 a	270.23 a	0.46 a	19.85 a	5.29 a	16.45 a
	GZL	63.93 ab	62.98 bc	35.71 a	25.44 a	17.09 ab	20.31 abc	11.29 a	133.96 a	290.35 a	0.46 a	18.94 ab	5.35 a	15.89 ab
	HEB	70.67 a	71.33 a	35.02 a	24.24 a	16.68 ab	20.49 ab	11.21 a	126.48 a	276.12 a	0.46 a	19.13 ab	5.36 a	15.58 ab
	CD	68.00 ab	69.00 ab	33.23 a	25.08 a	11.03 c	16.80 c	10.75 ab	58.64 c	220.33 bcd	0.27 c	16.84 bc	5.12 ab	15.15 ab
Mean squares (ANOVA)	Year df=1	0.21	0.08	0.46	0.11	0.02	1.48	2.37	4.77	2.13	11.88*	0.27	0.42	2.23
	Location df=6	4.12	3.92	0.82	0.44	4.39*	3.26	11.4**	20.64**	20.29**	40.54**	2.92	6.07*	2.27

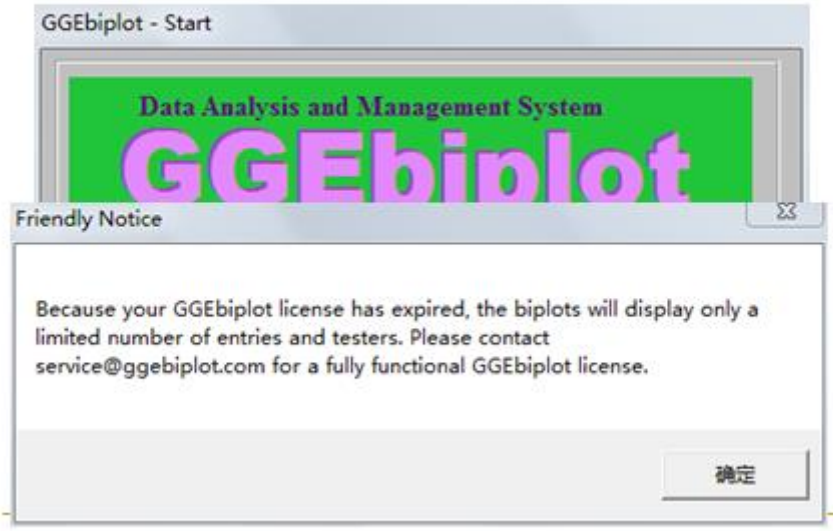
Letters indicate statistical significance at 0.05 level within the same column.
"*"and "**" represented significance at 0.05 and 0.01 probability level, respectively.

◆ Principal Component Analysis (PCA)

Table 4 Vector loadings and percentage of variation explained by the first three principal components after assessing 13 measured characteristics of Zhengdan 958

Characteristics	Principal components		
	1	2	3
Eigen values	6.731	2.730	1.367
Variation explained(%)	51.781	20.998	10.518
Cumulative percentage(%)	51.781	72.778	83.297
Eigenvalue vector			
Time of anthesis	-0.051	0.950	-0.041
Time of silk emergence	0.010	0.915	-0.127
Tassle: length of main axis above lowest lateral branch	0.332	0.040	0.847
Tassle: length of main axis above highest lateral branch	-0.038	-0.071	0.977
Tassel: number of primary lateral branches	0.853	0.262	-0.113
tassel: length of lateral branch	0.866	-0.123	0.274
Leaf: width of blade	0.256	0.820	0.065
Plant: height of insertion of peduncle	0.927	0.073	-0.014
Plant: length	0.883	0.294	0.096
Plant: ratio height of insertion of peduncle of upper ear to plant length	0.824	-0.178	-0.153
Ear: length	0.885	-0.031	0.161
Ear: diameter	0.747	0.481	0.083
Ear: number of rows of grain	0.804	0.181	0.052

◆ Biplot Analysis (GGE biplot software)



◆ Biplot Analysis (GGE biplot software)

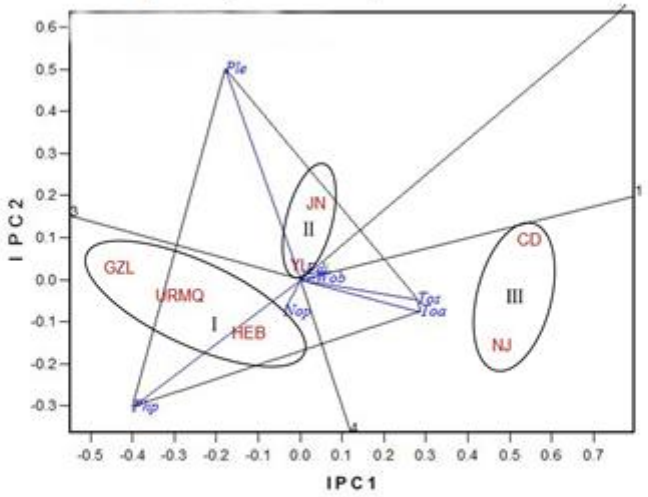


Fig.2 Biplot analysis of ecological regionalization based on 7 measured quantitative characteristics of Zhengdan 958 observed in different locations

This biplot was based on **h-weighted values relative to mean** (Scaling=5) and **double-centered** (Centering=3) locations and characteristics two way datasets with environment-focused singular value portioning (SVP=2) method. Ⅰ, Ⅱ and Ⅲ stand by different ecological regions, respectively.

Analysis of variance
-Zhengdan 958 in different locations over 2 years

◆ Ecological region

Table 6 Geographical factors of three ecological region divided by GGE biplot analysis

Ecological region	Trial location	Abbr. code	Longitude	Latitude	Altitude(m)
Ecological region I	Harbin, Heilongjiang	HEB	128° 32′	45° 45′	127
	Gongzhuling, Jilin	GZL	124° 42′	43° 25′	175
	Urumqi, Xinjiang	URMQ	87° 34′	43° 47′	947
Ecological region II	Jinan, Shandong	JN	117° 04′	36° 42′	27
	Yanglin, Shaanxi	YL	108° 04′	34° 15′	454
Ecological region III	Nanjing, Jiangsu	NJ	118° 24′	32° 20′	26.5
	Chengdu, Sichuan	CD	104° 06′	30° 36′	513

◆ Ecological regional feature of Zhengdan958

Table 7 The values of each characteristic of Zhengdan958 in different ecological regions

Characteristic	Ecological region		
	Ecological region I	Ecological region II	Ecological region III
Time of anthesis	68.1±0.31a	55.7±0.52b	67.00±1.09a
Time of silk emergence	68.13±0.89a	56.63±1.10b	66.25±1.22a
Tassle: length of main axis above lowest lateral branch	35.38±0.40a	34.14±0.43a	34.03±0.49a
Tassle: length of main axis above highest lateral branch	24.59±0.30a	24.87±0.24a	24.14±0.30a
Tassel: number of primary lateral branches	17.00±0.44a	11.14±0.49b	11.46±0.37b
Tassel: length of lateral branch	20.83±0.38a	19.33±0.37b	16.67±0.56c
Leaf: width of blade	11.00±0.12a	9.73±0.13b	10.80±0.14a
Plant: height of insertion of peduncle	128.34±2.75a	94.87±2.03b	72.93±2.29c
Plant: length	277.73±2.83a	227.99±2.81b	218.36±3.92c
Plant: ratio height of insertion of peduncle of upper ear to plant length	0.46±0.01a	0.42±0.01b	0.34±0.01c
Ear: length	19.07±0.29a	17.78±0.15b	16.61±0.22c
Ear: diameter	5.32±0.02a	4.86±0.04b	4.90±0.04b
Ear: number of rows of grain	15.87±0.16a	15.03±0.15b	15.14±0.28b

Values followed by different letters in the same row are significantly different at 5% probability level.
The mean±*SE* stands for the mean of each characteristic in corresponding ecological region and its standard error.

Results

- **No significant variance between years, while significant or extremely significant variance in locations (**ANOVA**);**
- **Stability of characteristics (**ANOVA**)**
  - 6 QNs (*Php,Ple et al.*) less stable;
  - 2 QNs (*Lol,Loh*) more stable;
- **Importance of characteristics (**PCA**)**
  - PC1, 8QNs (*Php,Ple et al.*) more important;
  - PC3, 2QNs (*Lol,Loh*) less important;

Results

- **Correlation of characteristics (**Biplot Analysis**);**
  - positive (*Toa, Tos*) / negative or uncorrelated (*Nop, Toa*);
- **Delineation of location (**Biplot Analysis**)**
  - divided into 3 regions related to latitude;
  - phenotype values of locations related to the length of characteristic-vector projection;
- **Feature analysis of ecological region (**ANOVA**);**
  - mutual verification

Conclusions

- **Stability and importance of QNs**
  - correlated
  - independent
- **'Reliable' characteristic**
  - more stable but less important
- **Ecological classification**
  - less stable but more important
- **Suitable ecological region**
  - YL and JN

Contents

- Analysis of variance for a variety Zhengdan 958 (hybrids, *Zea mays* L.) in different locations over two years
- **Analysis of variance for "variety × location" (environment) interaction of QN characteristics**

Analysis of variance
- 5 varieties in different locations with 10 QNs

- **Varieties:** Mo17, Dan340, Shen137, Danyu13, Zhong451 (*Zea mays* L.);
- **Locations:** Danzhou(DZ), Guangzhou(GZ), Chengdu(CD), Jinan(JN),Yanglin(YL),Nanjing(NJ), Gongzhuling(GZL), Harbin(HEB);
- **Year:** 2012;
- **Description:** on the basis of 11 measured quantitative characteristics.

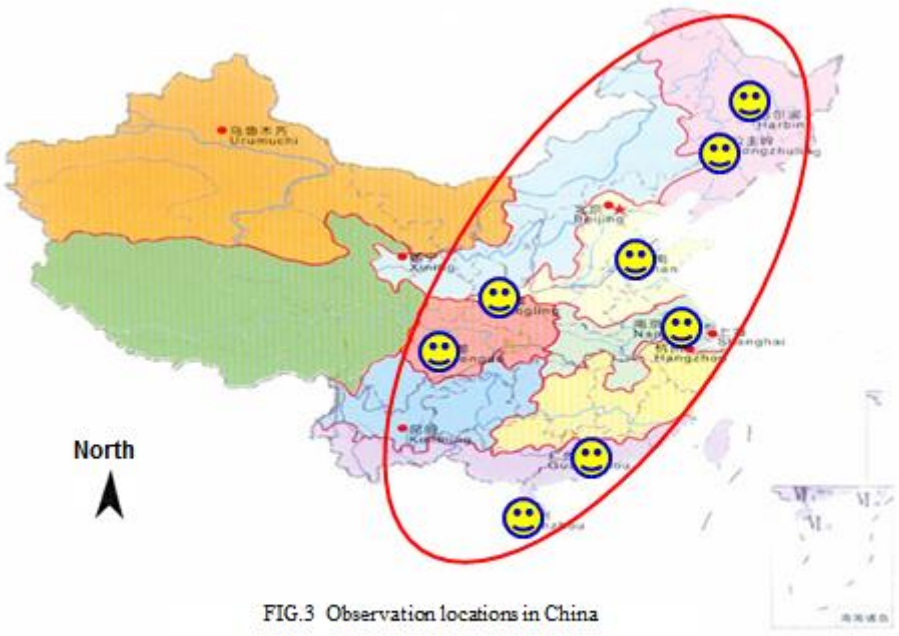


FIG.3 Observation locations in China

- **The results of analysis of variance**
  - 5 varieties in different locations with 11 QNs

Table 8 The joint analysis of variance of all the characteristics observed of different maize varieties in different locations

Experimental factors		*Lol*	*Loh*	*Nop*	*Lob*	*Wob*	*Php*	*Ple*	*Rhl*	*Ele*	*Edi*	*Ener*
Variety	MO17	35.12 b	27.52 a	5.83 c	17.19 b	9.15 cd	61.11 c	179.15 bc	0.337 c	14.89 b	3.38 c	10.57 d
	Dan340	27.49 d	20.84 c	11.77 b	14.24 c	8.79 d	56.78 c	170.12 c	0.324 c	13.19 cd	4.60 a	17.54 a
	Danyu13	37.35 a	26.95 a	14.28 a	19.16 a	10.85 a	80.88 a	216.93 a	0.367 b	19.36 a	4.62 a	14.98 b
	Shen137	30.55 c	21.00 c	11.04 b	19.50 a	9.57 b	74.01 b	181.61 b	0.396 a	14.11 bc	3.65 b	11.87 c
	Zheng451	29.92 c	23.55 b	5.15 c	16.56 b	9.27 bc	71.69 b	207.29 a	0.342 c	12.23 d	3.79 b	17.91 a
Location	CD	30.51 d	24.97 ab	10.48 bc	14.37 c	10.60 a	66.35 c	188.98 cd	0.347 b	13.98 cd	3.60 c	14.13 c
	YL	33.69 bc	24.92 ab	9.30 c	19.61 ab	8.76 dc	70.82 c	197.97 c	0.358 b	15.19 bc	3.89 d	15.20 b
	DZ	26.62 e	19.67 d	7.58 d	14.87 dc	8.37 c	48.99 d	153.44 e	0.308 c	13.23 d	3.62 c	12.46 d
	NJ	29.65 d	21.49 cd	10.40 bc	14.32 c	10.34 a	63.86 c	179.70 d	0.357 b	14.13 cd	4.07 cd	15.09 b
	GZ	31.20 cd	25.34 ab	5.00 c	17.10 cd	9.62 b	44.42 d	158.01 e	0.282 c	13.44 d	3.88 d	14.51 bc
	JN	32.10 cd	23.48 bc	10.72 b	17.81 bc	9.24 bc	69.34 c	194.04 c	0.356 b	14.97 c	4.20 bc	14.61 bc
	WEB	36.76 a	26.00 a	10.64 b	20.12 ab	9.13 cd	87.84 b	216.44 b	0.404 a	16.35 ab	4.41 a	14.63 bc
	GZL	36.14 ab	25.91 a	12.79 a	20.43 a	10.14 a	99.52 a	239.59 a	0.415 a	16.74 a	4.40 ab	15.96 a
Mean squares (ANOVA)	Variety df=4	30.98***	22.81***	139.08***	10.58***	36.74***	20.00***	29.66***	10.90***	57.05***	95.65***	271.46***
	Location df=7	13.59***	7.39***	31.08***	9.73***	22.98***	43.18***	37.66***	16.18***	7.90***	18.62***	16.17***
	variety×location df=28	0.89	1.21	5.73***	0.68	2.62**	2.34**	1.92*	2.10*	2.28**	4.31***	9.58***

Letters indicate statistical significance at 0.05 level within the same column.
"*", "**"and"***" represented significance at 0.05,0.01 and 0.0001 probability level, respectively.

Results

- **Significant or extremely significant variance between varieties and locations** (ANOVA);
- **Variety x location interaction** (ANOVA)
  - 8 QNs (*Php,Ple et al.*)
  - 3 QNs (*Lol,Loh,Lob*)
- **Genotypic and environmental effect**
  - 8/11 QNs dominated by genotype;
  - 3/11 QNs (*Php,Ple,Rhl*) dominated by environment;

GGE biplot analysis

- "Environmental Vector" View;
  - correlation of locations
- "Discriminating Ability vs. Representativeness" View
  - discriminating ability of locations
  - representative location
  - Average Environment Axis, AEA

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

- Tassle: length of main axis above lowest lateral branch

Table 9 The average and CV of *Lol* of 5 varieties in 8 different locations places

Variety \ Location	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	32.83	34.73	30.52	35.54	30.99	37.65	38.00	40.66	35.12	10.2
Den340	24.30	31.28	20.82	25.45	27.14	26.62	33.50	30.81	27.49	15.1
Shen137	34.07	40.40	30.82	35.25	38.79	34.84	43.30	41.33	37.35	11.4
Danyu13	31.11	32.30	26.80	24.35	31.04	29.50	35.20	34.07	30.55	11.8
Zhong451	30.23	29.76	24.11	27.67	28.05	31.89	33.80	33.82	29.92	11.1
MEAN	30.51	33.69	26.62	29.65	31.20	32.10	36.76	36.14		
CV(%)	12.4	12.3	16.0	18.1	14.7	13.5	11.1	12.8		

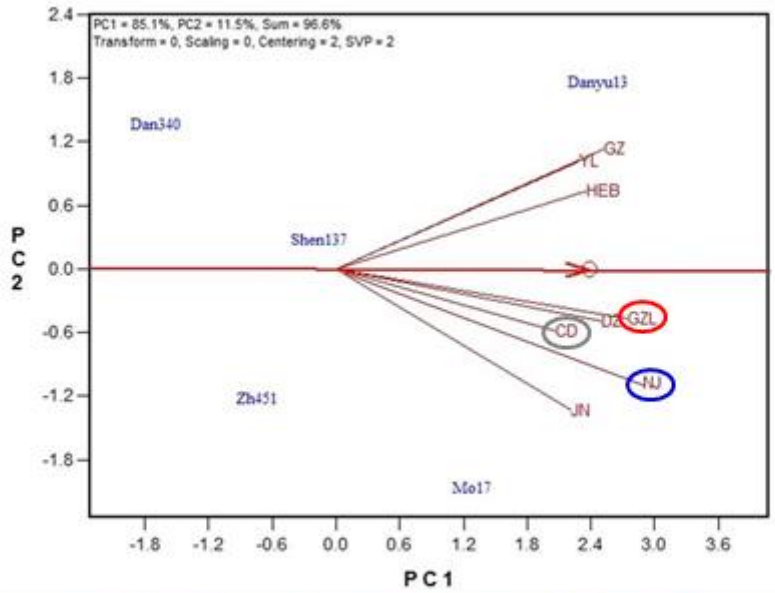


FIG.4 Environmental vector and discrimination view of the GGE biplot of *LoI*

◆ Correlation Analysis (SPSS)

Table10 Correlation coefficient of *LoI* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.661						
DZ	0.944*	0.786					
NJ	0.702	0.770	0.816				
GZ	0.758	0.958*	0.799	0.663			
JN	0.842	0.579	0.879*	0.914*	0.540		
HEB	0.754	0.987**	0.841	0.820	0.968**	0.672	
GZL	0.880*	0.837	0.961**	0.942*	0.799	0.928*	0.892*

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Tassle： length of main axis above highest lateral branch

Table 11 The average and CV of *Loh* of 5 varieties in 8 different locations places

Variety \ Location	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	27.23	26.92	22.23	27.48	26.90	30.55	27.60	31.26	27.52	9.9
Dan340	19.71	23.96	15.84	18.65	22.83	18.87	23.60	23.26	20.84	14.3
Shen137	27.58	28.88	21.81	24.56	28.64	23.74	31.00	29.38	26.95	11.9
Danyu13	26.01	21.73	19.59	16.45	23.94	18.50	22.30	19.51	21.00	14.7
Zhong451	24.33	23.10	18.89	20.31	24.39	25.73	25.50	26.15	23.55	11.2
MEAN	24.97	24.92	19.67	21.49	25.34	23.48	26.00	25.91		
CV(%)	12.8	11.7	13.1	20.8	9.4	21.4	13.2	18.2		

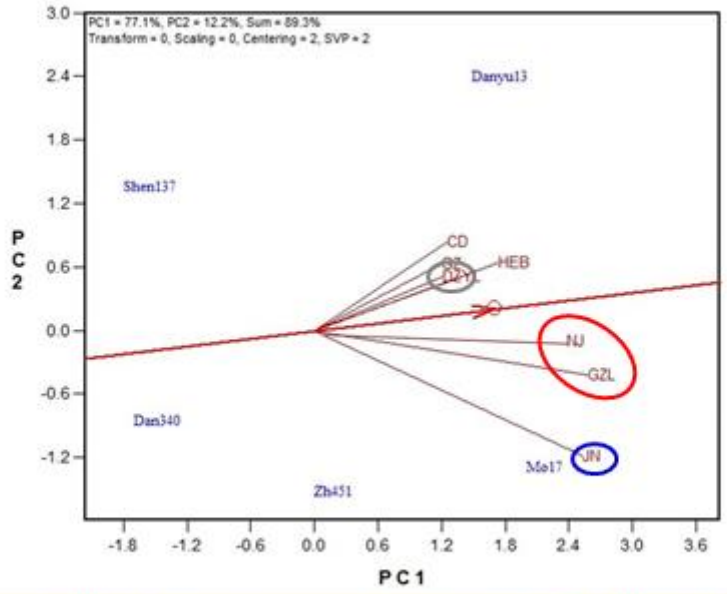


FIG.5 Environmental vector and discrimination view of the GGE biplot of *Loh*

◆ Correlation Analysis (SPSS)

Table12 Correlation coefficient of *Loh* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.474						
DZ	0.969**	0.631					
NJ	0.558	0.862	0.741				
GZ	0.806	0.895*	0.883*	0.819			
JN	0.532	0.534	0.676	0.874	0.593		
HEB	0.585	0.947*	0.698	0.828	0.941*	0.593	
GZL	0.468	0.854	0.653	0.975**	0.788	0.880*	0.862

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Tassle： number of primary lateral branches

Table 13 The average and CV of *Nop* of 5 varieties in 8 different locations places

Variety \ Location	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	5.00	4.88	7.32	7.70	3.00	4.45	7.00	7.25	5.83	29.5
Den340	9.42	13.59	9.18	11.40	5.00	13.14	16.00	16.45	11.77	32.6
Shen137	20.75	12.29	9.98	15.40	8.00	18.62	12.20	17.00	14.28	30.8
Denyu13	11.92	10.39	7.53	12.50	6.00	11.00	13.30	15.70	11.04	28.2
Zhong451	5.33	5.35	3.87	5.00	3.00	6.37	4.70	7.55	5.15	27.3
MEAN	10.48	9.30	7.58	10.40	5.00	10.72	10.64	12.79		
CV(%)	61.3	42.9	31.0	39.3	42.4	52.5	43.8	38.6		

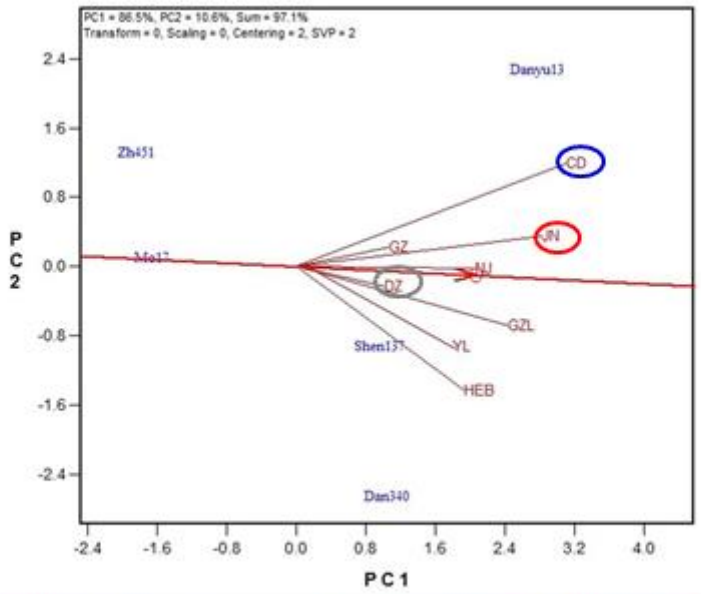


FIG.6 Environmental vector and discrimination view of the GGE biplot of *Nop*

◆ Correlation Analysis (SPSS)

Table14 Correlation coefficient of *Nop* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.705						
DZ	0.718	0.793					
NJ	0.913*	0.840	0.889*				
GZ	0.981**	0.792	0.756	0.960**			
JN	0.939*	0.882*	0.766	0.901*	0.947*		
HEB	0.540	0.943*	0.802	0.796	0.671	0.713	
GZL	0.794	0.972**	0.789	0.916*	0.885*	0.903*	0.925*

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Tassle： length of lateral branch

Table 15 The average and CV of *Lob* of 5 varieties in 8 different locations places

Location / Variety	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	12.89	18.78	15.66	15.76	15.90	18.50	19.30	20.72	17.19	14.9
Dan340	13.13	16.56	10.61	12.60	15.48	12.32	16.10	17.16	14.24	16.7
Shen137	14.06	22.69	16.42	14.93	20.57	18.51	23.60	22.48	19.16	19.4
Danyu13	18.21	21.65	16.62	15.40	20.48	19.75	21.60	22.29	19.50	12.9
Zhong451	13.54	18.38	15.02	12.90	13.11	19.98	20.00	19.54	16.56	19.4
MEAN	14.37	19.61	14.87	14.32	17.10	17.81	20.12	20.43		
CV(%)	15.3	12.8	16.6	10.2	19.3	17.7	13.9	10.7		

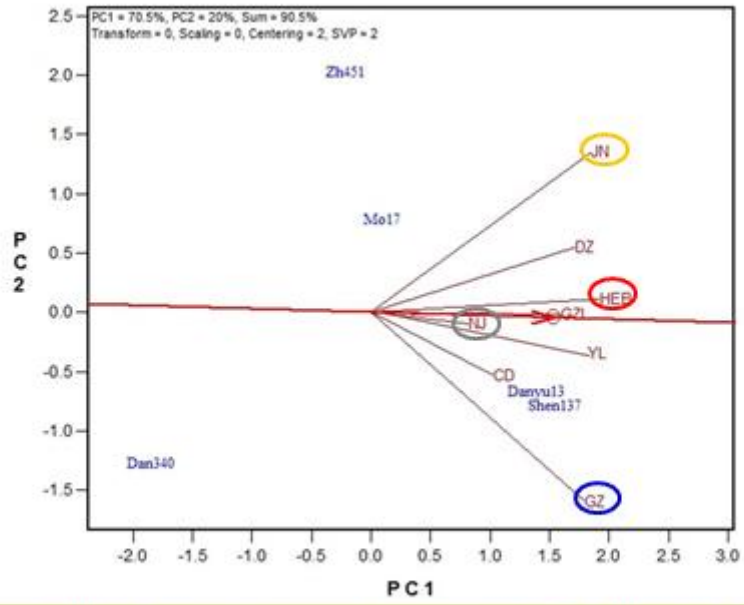


FIG.7 Environmental vector and discrimination view of the GGE biplot of *Lob*

◆ Correlation Analysis (SPSS)

Table16 Correlation coefficient of *Lob* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.587						
DZ	0.473	0.830					
NJ	0.400	0.672	0.768				
GZ	0.657	0.860	0.513	0.647			
JN	0.406	0.622	0.927*	0.536	0.202		
HEB	0.445	0.958*	0.889*	0.589	0.681	0.756	
GZL	0.565	0.952*	0.947*	0.822	0.758	0.771	0.936*

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Leaf: width of blade

Table 17 The average and CV of *Wob* of 5 varieties in 8 different locations places

Variety \ Location	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	10.68	7.95	7.80	10.88	9.63	8.60	8.25	9.44	9.15	13.1
Den340	10.03	8.41	6.99	9.72	8.60	8.55	8.65	9.37	8.79	10.7
Shen137	11.92	10.74	9.83	10.25	11.50	10.06	10.65	11.88	10.85	7.5
Denyu13	9.79	8.88	8.88	10.65	8.89	10.50	8.95	9.99	9.57	8.0
Zhong451	10.58	7.80	8.34	10.22	9.50	8.49	9.15	10.05	9.27	10.7
MEAN	10.60	8.76	8.37	10.34	9.62	9.24	9.13	10.14		
CV(%)	7.8	13.6	12.8	4.3	11.8	10.4	10.0	10.0		

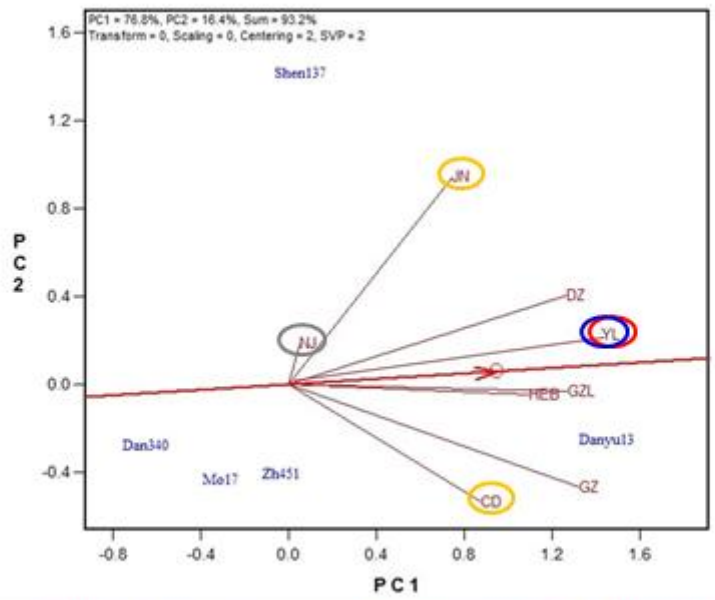


FIG.8 Environmental vector and discrimination view of the GGE biplot of *Wob*

◆ Correlation Analysis (SPSS)

Table18 Correlation coefficient of *Wob* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.681						
DZ	0.635	0.769					
NJ	0.020	-0.116	0.302				
GZ	0.978**	0.763	0.776	0.127			
JN	0.132	0.712	0.768	0.285	0.323		
HEB	0.779	0.886*	0.837	-0.228	0.837	0.539	
GZL	0.834	0.901*	0.898*	-0.051	0.905*	0.583	0.982**

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Plant： height of insertion of peduncle

Table 19 The average and CV of *Php* of 5 varieties in 8 different locations places

Variety \ Location	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	43.67	67.12	56.81	54.90	48.50	52.80	72.00	93.10	61.11	26.0
Den340	47.08	61.21	34.85	49.90	32.20	71.57	72.00	85.40	56.78	33.4
Shen137	82.58	90.48	54.56	80.60	50.32	80.47	101.30	106.70	80.88	24.8
Danyu13	78.08	67.90	44.41	62.00	38.86	71.50	112.40	116.90	74.01	38.3
Zhong451	80.33	67.37	54.34	71.90	52.22	70.36	81.50	95.50	71.69	20.0
MEAN	66.35	70.82	48.99	63.86	44.42	69.34	87.84	99.52		
CV(%)	29.0	16.0	18.9	19.6	19.3	14.6	20.7	12.4		

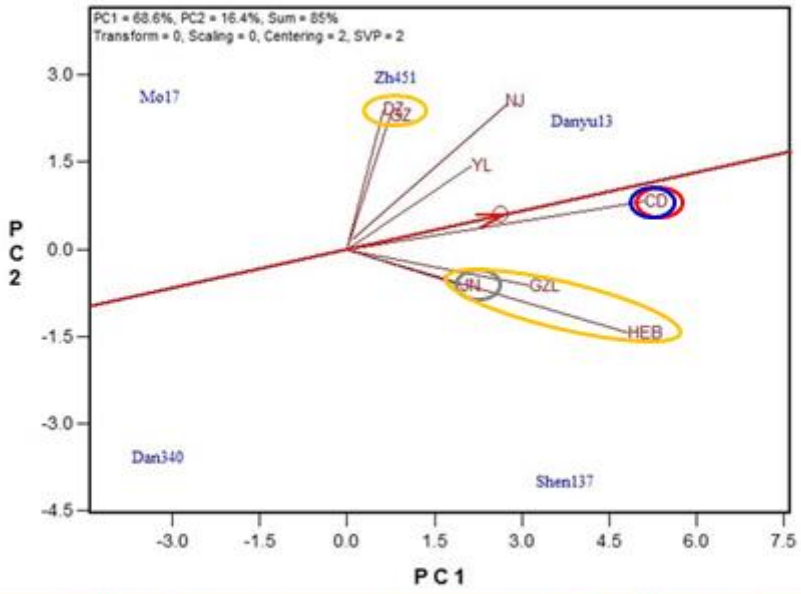


FIG.9 Environmental vector and discrimination view of the GGE biplot of *Php*

◆ Correlation Analysis (SPSS)

Table20 Correlation coefficient of *Php* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.580						
DZ	0.290	0.505					
NJ	0.868	0.838	0.589				
GZ	0.429	0.536	0.964**	0.716			
JN	0.710	0.544	-0.277	0.610	-0.096		
HEB	0.772	0.516	0.043	0.541	0.036	0.575	
GZL	0.717	0.471	0.193	0.503	0.144	0.377	0.972**

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Plant： length

Table 21 The average and CV of *Ple* of 5 varieties in 8 different locations places

Location / Variety	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	169.75	194.82	169.82	162.70	139.80	178.45	203.00	214.85	179.15	13.5
Den340	147.50	178.89	124.42	164.80	137.21	193.62	198.30	216.25	170.12	18.9
Shen137	218.33	230.81	168.56	212.70	190.88	204.59	246.30	263.30	216.93	13.9
Denyu13	183.58	173.08	135.04	153.00	143.52	180.50	220.00	264.15	181.61	23.5
Zhong451	225.75	212.26	169.35	205.30	178.67	213.03	214.60	239.40	207.29	11.2
MEAN	188.98	197.97	153.44	179.70	158.01	194.04	216.44	239.59		
CV(%)	17.4	12.0	14.3	15.2	15.8	7.7	8.7	10.1		

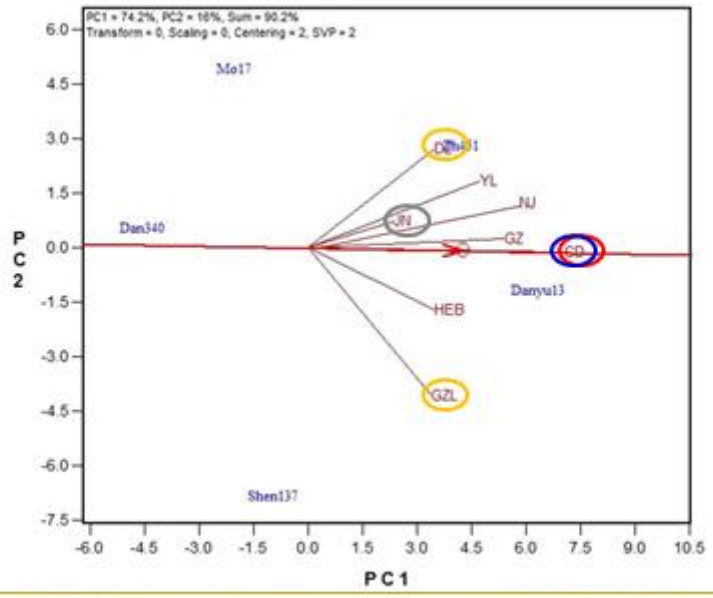


FIG.10 Environmental vector and discrimination view of the GGE biplot of *Ple*

◆ Correlation Analysis (SPSS)

Table22 Correlation coefficient of *PLe* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.788						
DZ	0.697	0.803					
NJ	0.836	0.943*	0.648				
GZ	0.920*	0.921*	0.639	0.965**			
JN	0.709	0.708	0.355	0.898*	0.822		
HEB	0.726	0.698	0.401	0.654	0.807	0.398	
GZL	0.631	0.299	0.083	0.339	0.565	0.214	0.855

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Ear: length

Table 23 The average and CV of *Els* of 5 varieties in 8 different locations places

Variety \ Location	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	13.53	15.65	14.45	13.08	14.00	16.58	15.50	16.32	14.89	8.8
Dan340	9.22	13.60	13.30	14.21	11.60	13.75	14.35	15.45	13.19	14.7
Shen137	18.62	20.90	17.19	16.27	17.46	20.15	23.05	21.20	19.36	12.1
Denyu13	16.08	15.10	11.60	13.05	13.53	13.50	13.45	16.60	14.11	11.9
Zhong451	12.48	10.72	9.59	14.04	10.61	10.88	15.40	14.15	12.23	17.2
MEAN	13.98	15.19	13.23	14.13	13.44	14.97	16.35	16.74		
CV(%)	25.5	24.5	21.8	9.3	19.7	23.6	23.5	15.9		

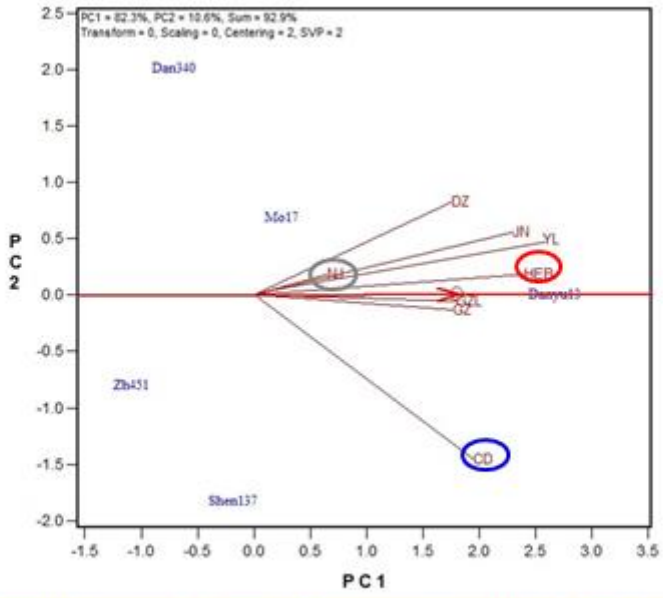


FIG.11 Environmental vector and discrimination view of the GGE biplot of *Els*

◆ Correlation Analysis (SPSS)

Table24 Correlation coefficient of *Ele* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.760						
DZ	0.475	0.923*					
NJ	0.421	0.621	0.616				
GZ	0.837	0.987**	0.877	0.580			
JN	0.638	0.965**	0.977**	0.609	0.950*		
HEB	0.662	0.798	0.760	0.909*	0.804	0.811	
GZL	0.803	0.981**	0.871	0.735	0.972**	0.924*	0.871

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Ear: diameter

Table 25 The average and CV of *Edi* of 5 varieties in 8 different locations places

Variety \ Location	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	2.69	3.20	3.28	3.62	2.95	3.88	3.74	3.67	3.38	12.3
Den340	3.34	4.52	4.46	5.02	4.56	4.63	5.29	5.00	4.60	12.8
Shen137	4.23	4.75	4.05	4.38	4.58	4.84	5.08	5.05	4.62	8.2
Denyu13	3.90	3.54	3.12	3.41	3.73	4.10	3.43	4.00	3.65	9.2
Zhong451	3.83	3.43	3.20	3.91	3.60	3.55	4.51	4.30	3.79	11.6
MEAN	3.60	3.89	3.62	4.07	3.88	4.20	4.41	4.40		
CV(%)	16.6	17.9	16.5	15.9	17.8	12.7	18.4	13.8		

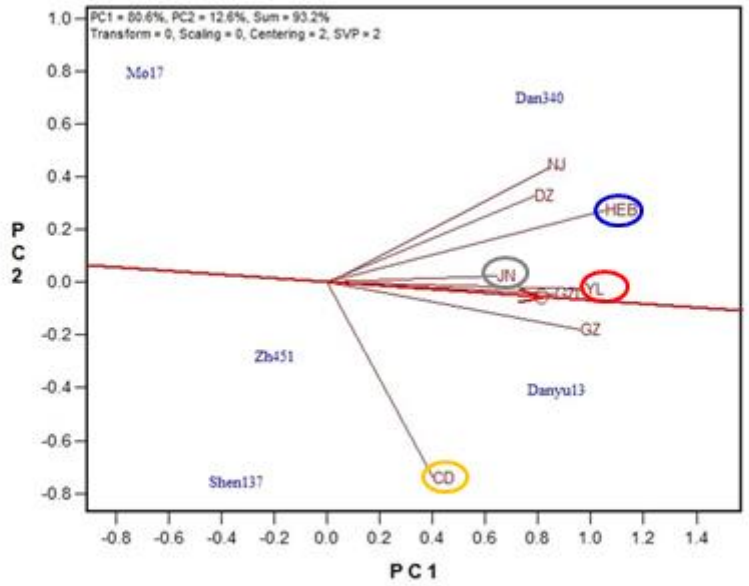


FIG.12 Environmental vector and discrimination view of the GGE biplot of *Edi*

◆ Correlation Analysis (SPSS)

Table26 Correlation coefficient of *Edi* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.476						
DZ	0.080	0.899*					
NJ	0.080	0.823	0.960**				
GZ	0.603	0.959**	0.833	0.798			
JN	0.317	0.928*	0.840	0.672	0.839		
HEB	0.273	0.833	0.875	0.943*	0.804	0.610	
GZL	0.531	0.957*	0.873	0.878	0.966**	0.782	0.926*

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

Variation of variety descriptions
-5 varieties in different locations with 10 QNs

◆ Ear： number of rows of grain

Table 27 The average and CV of *Env* of 5 varieties in 8 different locations places

Variety \ Location	CD	YL	DZ	NJ	GZ	JN	HEB	GZL	MEAN	CV(%)
Mo17	11.17	10.53	9.61	11.27	10.00	10.50	9.80	11.70	10.57	7.1
Dan340	11.50	18.80	15.23	19.20	17.50	20.50	18.60	19.00	17.54	16.4
Shen137	14.33	16.40	13.88	14.40	14.25	15.05	14.80	16.70	14.98	6.9
Denyu13	13.50	12.80	9.99	11.00	14.20	10.00	10.93	12.50	11.87	13.5
Zhong451	20.17	17.47	13.60	19.60	16.58	17.00	19.00	19.90	17.91	12.4
MEAN	14.13	15.20	12.46	15.09	14.51	14.61	14.63	15.96		
CV(%)	25.7	22.6	20.2	27.5	20.0	30.4	29.0	23.3		

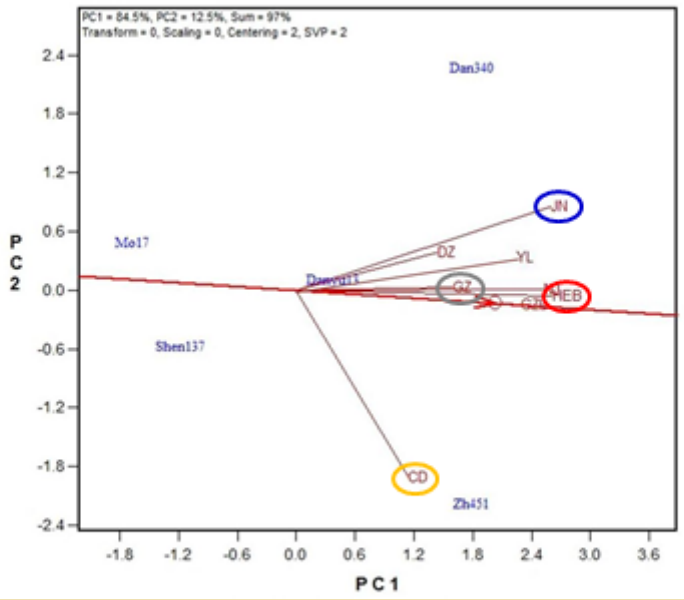


FIG.13 Environmental vector and discrimination view of the GGE biplot of *Env*

◆ Correlation Analysis (SPSS)

Table28 Correlation coefficient of *Env* among the locations used for biplot analysis

Location	CD	YL	DZ	NJ	GZ	JN	HEB
CD							
YL	0.398						
DZ	0.271	0.972**					
NJ	0.501	0.909*	0.876				
GZ	0.430	0.927*	0.819	0.835			
JN	0.219	0.943*	0.960**	0.939*	0.823		
HEB	0.530	0.960**	0.919*	0.986**	0.889*	0.941*	
GZL	0.569	0.958*	0.927*	0.973**	0.864	0.925*	0.995**

*significant correlation at 0.05 probability level;
** significant correlation at 0.01 probability level.

◆ Variation of variety descriptions

Table 29 Coefficient of variation of 11 QNs

Ch.	*Lol* (%)	*Lok* (%)	*Nsp* (%)	*Lob* (%)	*Wob* (%)	*Php* (%)	*Pla* (%)	*Rhl* (%)	*Ela* (%)	*Edi* (%)	*Enr* (%)
Variety	10.2~15.1	9.9~14.7	27.3~32.6	12.9~19.4	7.5~13.1	20.0~38.3	11.2~23.5	10.7~18.5	8.8~17.2	8.2~12.8	7.1~16.4
Location	11.1~18.1	9.4~21.4	31.0~61.3	10.2~19.3	4.3~13.6	12.4~29.0	7.7~17.4	7.7~17.4	9.3~25.5	12.7~18.4	20.0~25.7

◆ No or negative correlation among some locations (Biplot Analysis)

Table 30 Ecological region delineation of some locations based on biplot analysis of some QNs

Characteristic	Ecological region "A"	Ecological region "B"
Lob	GZ	JN
Wob	CD,GZ	NJ,JN
Php	DZ,GZ	JN,GZL,HEB
Pla	DZ	GZL
Ela	CD	
Edi	CD	NJ,DZ
Enr	CD	JN

Results

- **Extremely significant variance in locations and varieties (**ANOVA**);**
- **"variety × location" interaction (**ANOVA**)**
  - 6 QNs (*Nop,Php et al.*) extremely significant;
  - 2 QNs (*Ple,Rhl*) significant;
  - 3 QNs (*Lol,Loh,Lob*) not significant;
- **Environmental main effect (**ANOVA**)**
  - 3QNs (*Php,Ple Rhl*);

Conclusions

- **Discriminating ability of location(**Biplot Analysis**)**
  - depends on the vector length;
  - correlated to CV of locations;
- **Relationships of locations(**Biplot Analysis**)**
  - depends on the vector angles;
  - clarify locations in different ecological region;

Thanks for your attention!

[End of Annex and of document]