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Comparison of Performance and Stability Parameters for Soybean Yield

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ABSTRACT : Ten selected soybean genotypes, consisting of nine from a pedigree breeding programme and one recommended variety, were evaluated in nine different locations and over two years for stability of yield performance. Variance component analysis revealed that soybean regional yield trials should be performed at more locations rather than in more years. Five stability parameters, which were coefficient of variability, regression coefficient, deviation parameter, variance component for genotype×environment interaction, and ecovalence, were employed in the evaluation. Significant genotype×environment interaction was present with respect to soybean yield. The highest average yield over nine locations and two years was shown in Suwon 145, which was considered to be stable in all stability statistics. In rank correlation among stability parameters, there were highly significant correlations among stability parameters derived from three Eberhart and Russell's, Plaisted's, and Wricke's methods. Due to the different ranking of genotypes by different stability parameters, a comprehensive method should be employed to identify the promising genotype as well as to characterize the relationship between genotype and environment.

Key words : Soybean, Stability parameter, Coefficient of variability, Regression coefficient, Deviation parameter, Variance component, Ecovalence.

Exact estimates of genotype × environment(G×E) interactions are of major concern to the plant breeder in developing improved varieties. It is difficult to determine which variety is high and stable in yield performance, when varieties are tested over several locations and years[7]. Therefore, a greater emphasis has been placed on the phenotypic stability in breeding programs.

The methods for detecting stable genotypes were reviewed extensively by Lin et al.[6] Nine stability parameters were classified

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into four groups on the basis of the deviation from the average genotype effect, the G×E interaction term, sum of squares, regression coefficient or deviation. Of the stability statistics the regression approaches developed by Finlay and Wilkinson[4], and Eberhart and Russell[3] have been widely used. In addition, another methods employed were the variance component for G×E interaction[8] and the Wricke's ecovalence[6]. Comparison among these stability parameters has been done continuously[1,2,6]. In soybean regional trials in Korea, the conventional coefficient of variability (CV), suggested by Francis and Kannenberg[5], has been adopted dominantly in measuring stability of tested genotypes.

Interest in soybean yield stability has been on the rise due to considerable variation in yield from regional trials in spite of narrow land in Korea. The purposes of this study were to compare the effectiveness of different stability statistics, and to identify the genotype with high yield and stablity in regional soybean yield trial in which ten selected genotypes were tested over two years and nine locations.

MATERIALS AND METHODS

The experimental material was comprised of ten soybean genotypes including nine originated from pedigree breeding programmes and one recommended variety. The genotypes Paldalkong, Suwon 145, Suwon 146, Suwon 150, and Suwon 151 were developed from National Crop Experiment Station(NCES) located at northern part of South Korea, and Milyang 28, Milyang 32, and Milyang 33 from National Yeongnam Agricultural Experiment Station at southeastern part, and Mokpo 9 and Mokpo 12 from Mokpo Branch Station of NCES (presently belongs to National Honam Agricultural Experiment Station) at southwestern part.

Ten selected genotypes were grown over two years(1990~1991) and nine locations. A randomized block design was employed in each experimental site with four replications. Row spacing was 0.6m, and population was 15.3 plants/m within row. Plot size was 4 rows × 4.1m, and two rows in the middle of plot were harvested to determine yied.

Stability parameters estimated were: 1) coefficient of variability (CV)[5], 2) coefficient regressed on the difference between the marginal mean of the environments and the total mean(b_i)[4], 3) sum of squared deviations from regression (δ_i^2)[3], 4) variance component for G×E interaction estimated with the remainder when successive genotypes are omitted from the analysis($\theta_{(i)}$)[8], 5) G×E interaction across all environments corresponding to each genotype (ω_i^2)[6]. For comparison among stability parameters, rank correlation coefficients were used.

RESULTS AND DISCUSSION

Soybean yield was determined from ten selected genotypes at nine different locations over two years. Table 1 shows mean soybean yield and coefficient of variability corresponding to year and location. The yield difference was great between locations and years. When averaged across all genotypes used, soybean yield ranged from 2,100 (Muahn) to 3,083kg/ha(Suwon) in 1990, and from 2,025(Muahn) to 3,183kg/ha(Sangju) in 1991. Also, great yearly variation in soy-

Table 1. Means and coefficients of variation of soybean yield grown at nine locations in 1990 and 1991

Locations	1990		1991	
	Mean	C.V.	Mean	C.V.
	-kg/ha-	%	-kg/ha-	%
Suwon	3,083	17.5	2,485	16.9
Muahn	2,100	9.8	2,025	14.4
Iksan[1)]	3,034	9.7	2,562	10.3
Milyang	3,021	8.3	2,700	10.8
Sangju	2,550	20.7	3,183	10.2
Iksan[2)]	3,051	11.1	2,653	10.1
Kwangju	2,649	13.3	2,973	10.7
Taegu	3,009	8.0	2,629	18.5
Chinju	2,874	7.6	2,855	6.6
Average	2,819	16.5	2,674	16.7

1) Experimental site at the National Honam Agricultural Experiment Station, and 2) at Chonbuk Provincial Rural Development Administration.

Table 2. Analysis of variance for yield of ten soybean genotypes grown at nine locations in 1990 and 1991

Source	df	Mean square	Variance component
Replications	3	1,842*	7.0
Genotypes(G)	9	7,036**	89.7
Years(Y)	1	37,976**	103.9
Locations(L)	8	53,403**	660.3
G×Y	9	2,260**	46.8
G×L	72	3,119**	317.9
Y×L	8	32,120**	788.6
G×Y×L	72	2,549**	493.3
Error	537	576	576.0

bean yield averaged across all genotypes was observed. Specifically, soybean yield in Sangju was 2,550kg/ha in 1990 and 3,183 kg/ha in 1991.

The significant difference among genotypes and their interactions with year or location in the combined analysis of variance for yield(Table 2) suggested that yield of soybean genotypes responded differentially corresponding to year and location. The effect of location varied considerably from year to year, evidenced from the presence of significant interaction effect between genotype and year. Therfore, it was not easy to identify the best genotypes with this simple analysis of variance. The variance component due to genotype×location(G×L) was about seven times larger than that due to genotype, and also larger than that due to genotype×year(G×Y). This indicated that yield performance of genotypes was more varied across locations than across years. Related to that, exact evaluation in soybean regional yield trial could be achieved by testing soybean genotypes at more locations rather than in more years at small number of experimental sites.

Table 3 gives data on mean yield and stability parameters of genotypes. Mean yields of ten soybean genotypes across all environments ranged from 2,585 to 2,932kg/ha. Suwon 145 had the highest yield followed by Suwon 151, Milyang 33, and Mokpo 9. Milyang 32 showed the lowest yield. Significant interaction effect(Table 2) of G×Y and G×L as well as year × location(Y×L) suggested that unpredictable environments contributed to the variability mostly. This allows evaluation of genotypes for stability of yield performance across different environements by making year and location combinations into one single factor[7)]. Stability parameters were estimated with five different methods(Table 3). On the basis of coefficient variability, Paldalkong was the most stable in yield performance, but it was not in any other stability parameters. Contrary to this, Suwon 151 and Milyang 32 were fairly stable in view of regression coefficient analysis. Analysis of GE interaction term or regression deviation revealed that higher stab-

Table 3. Yield and stability parameters of ten selected soybean genotypes

Genotype	Yield	Stability parameters				
	(kg /ha)	CV	$\|b_i-1\|$	δ_i^2	$\theta_{(1)}$	ω_i^2
Paldalkong	$2,706^{de}$	10.9	0.51	336.5	558.8	10,367
Suwon 145	$2,932^{a}$	11.6	0.10	124.9	602.3	5,542
Suwon 146	$2,691^{e}$	14.4	0.12	128.2	596.5	5,533
Suwon 150	$2,656^{ef}$	17.5	0.14	165.4	570.6	8,516
Suwon 151	$2,843^{b}$	11.8	0.04	188.3	550.1	11,850
Milyang 28	$2,744^{cde}$	14.9	0.06	301.6	596.4	5,619
Milyang 32	$2,858^{f}$	19.8	0.04	939.4	411.2	27,322
Milyang 33	$2,796^{bc}$	15.5	0.38	109.7	580.0	4,186
Mokpo 9	$2,791^{bcd}$	14.2	0.08	658.2	549.9	11,941
Mokpo 12	$2,717^{cde}$	16.9	0.13	697.2	544.8	12,667

ility was shown in Suwon 145 and Suwon 146.

Based on the stability and yield performance, the highest average yield over nine locations and two years was shown in Suwon 145, which was considered to be stable in most of all stability statistics. In 1992, Suwon 145 was named as 'Taekwangkong', registered and released to the farmers as a recommended variety. On the other hand, Milyang 33 was low in yield stability, but showed fairly high yield. Milyang 33 was thought to be recommended in a specifically localized area, and registered as 'Bukwangkong' in 1993. Bukwangkong has been recommended in the southern part of Korea.

Rank corrleation analysis among stability parameters was shown in Table 4. In rank correlation, there were highly significant correlations among stability parameters derived from three Eberhart and Russell's, Plaisted's, and Wricke's methods. But there was no significant correlation between CV or regression coefficient and any other parameters, suggesting that the use of different stability parameters will cause different ranking of genotype. This is consistent with the results reported by Becker[2]. Different ranking of soybean genotypes by different stability parameters in this study emphasized the use of comprehensive stability analyses for identifying the superior genotype in the regional soybean yield trials.

Table 4. Rank correlation among stability parameters.

	$\|b_i-1\|$	δ_i^2	$\theta_{(1)}$	ω_i^2
CV	−0.079	0.261	−0.382	0.248
$\|b_i-1\|$		−0.340	0.243	−0.413
δ_i^2			-0.842^{**}	0.927^{**}
$\theta_{(1)}$				-0.915^{**}

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적 요

수원 작물시험장 등 전국 각도 9개 지역에서 1990 및 1991년에 걸쳐 수행된 콩 지방적응연락 시험에서, 팔달콩 등 10개의 공시계통들의 평균

수량을 조사하였으며, 수량안정성을 여러가지 방법으로 분석하여 상호 비교하였다. 수량 안정성 분석은 Francis와 Kannenberg의 coefficient of variability, Finlay와 Wilkinson의 regression coefficient, Eberhart와 Russell의 deviation parameter, Plaisted의 variance component, Wricke의 ecovalence 등 5개 분석방법을 이용하였으며 그 결과를 요약하면 다음과 같다.

1. 분산성분 비교에 의하면, 수량에 대한 콩유전자와 지역간 상호작용 분산성분이 콩유전자 및 년차간 상호작용 분산성분보다 약 7배 높아서, 정확한 수량안정도 평가를 위해서는 여러 해 걸쳐서 콩계통을 평가하기보다는 더 많은 지역에서 평가되어야 할 것으로 보였다.
2. 2년차 9개지역에서 수원 145호('92년 태광콩으로 장려품종 지정)가 평균수량이 높았으며, 5개 안정성 분석결과 수량안정도도 높았다.
3. 안정도계수 종류들 간의 rank correlation 분석결과, Eberhart와 Russell, Plaisted, 그리고 Wricke의 방법들 간의 고도의 유의적인 상관관계가 있었으나, Francis와 Finlay 방법은 다른 분석방법들과는 상관관계가 인정되지 않았다.

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