Perform Stability of Linolenic Acid Content of Soybean Recombinant Intercross Line Evaluated by GGE Biplot

HAN Ying-peng [1], SUN Ming-ming[1,2], LIU Hao-fei[3], ZHAO Xue[1], TENG Wei-li[1], LI Wen-bin[1]

(1. Key Laboratory of Soybean Biology in Chinese Ministry of Education, Key Laboratory of Soybean Biology and Breeding/Genetics of Chinese Agriculture Ministry, Northeast Agricultural University, Harbin 150030, China; 2. Information Center, Heilongjiang Academy of Agricultural Sciences, Harbin 150086, China; 3. Heilongjiang Acadeny of Agricultual Sciences, Harbin 150086, China)

Abstract: Linolenic acid (LN) in soybean seed mainly contributes to the undesirable odors and flavors commonly associated with poor oil quality. The aim of this study was to evaluate perform stability of a recombinant intercross line (RIL) derived from 'Hefeng 25' and 'Dongnong L-5'. Location attributed higher proportion of the variation in the data (35%), while genotype contributed to 60% of total variation. Genotype × location interaction contributed only 5% of total variation. We could identify superior genotype for LN content *via* GGE biplot graphical approach effectively. Tested locations were highly correlated. 'Which-won-where' study partitioned the tested locations into three environments, the result showed that P63 and P25 were super genotypes for Harbin in 2007 and 2008, and Harbin in 2009, respectively.

Key words: Soybean; Linolenic acid; Stability; GGE biplot

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GGE 双标图法评价大豆重组自交系亚麻酸表现的稳定性

韩英鹏[1],孙明明[1,2],刘昊飞[3],赵 雪[1],滕卫丽[1],李文滨[1]

(1. 东北农业大学 大豆生物学教育部重点实验室,农业部北方大豆生物学与遗传育种区域重点实验室,黑龙江 哈尔滨 150030;2. 黑龙江省农业科学院 信息中心,黑龙江 哈尔滨 150086;3. 黑龙江省农业科学院,黑龙江 哈尔滨 150086)

摘要: 亚麻酸是大豆油中不良气味的主要来源之一,并且与大豆油品质密切相关,本研究对东农 L-5 与合丰 25 杂交以后产生的重组自交后代的亚麻酸含量的稳定性进行了研究。结果表明:环境变异为总变异的 35% 左右,而基因型变异占总变异的 60% 左右,环境与基因型互作占总变异的 5% 左右。通过 GGE 双标图方法有效地筛选了重组自交系中的亚麻酸表现最稳定的基因型,并且发现 3 个测试环境是高度相关的。基因型的环境适应性分析表明:后代家系 P63 在 2007、2008 年和 P25 在 2009 年哈尔滨的环境条件下具有最稳定的表现。

关键词: 大豆;亚麻酸;稳定性;GGE 双标图

Soybean was a important oil crop, and production of which accounted for approximately 195 million metric ton of oilseed annually[1]. This represents almost 60% of the total oilseed production in the world. Soybean oil is used in a wide array of edible and industrial oil applications such as cooking oil, margarine, lubricants, inks and biodiesel fuel. A typical oil concentration in soybean is 20% of seed dry weight and its quality is determined by fatty acid composition. There are five predominant fatty acids, including palmitic, stearic, oleic, linoleic and linolenic acids [1]. Linolenic acids (LN) was accounted for the undesirable odors and shorter self life associated with poor oil quality[2-3]. Traditional soybean improvement has relied on phenotypic selection of populations from crosses between commercial cultivars or experimental lines[4-5]. Selections for soybean cultivars with reasonable and stable LN content required evaluation in multiple environments over several years, which was expensive, time-consuming and labor intensive.

GGE biplot offered a faster and more accurate approach to breeding, biplot analysis could identify 'which-won-where' besides identifying different GGE biplot analysis has been used to analyze perform of many crop across multi-environments including to date, GGE analysis still wasn't used to analyze fatty acid of recombinant intercross line (RIL).

In this study, we analyzed the LN performance of a RIL population derived from a cross between 'Hefeng 25' and 'Dongnong L-5' using GGE biplot.

1 Material and methods

1.1 Plant materials

The mapping population of 125 $F_{5:7}$, $F_{5:8}$ and $F_{5:9}$ RILs derived from the cross between 'Hefeng 25' and 'Dongnong L-5' through single-seed-descent.

1.2 Field design and evaluation of linolenic acid

One hundred and twenty-five RIL and parents

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Biography: HAN Ying-peng (1978-), male, PhD, professor. Major in molecular breeding. E-mail: hyp234286@aliyun.com.

Corresponding author: LI Wen-bin (1958-), male, PhD, professor. Major in molecular breeding. E-mail: wenbinli@neau.edu.cn.

were grown in a randomized complete block design at Harbin during 2007, 2008 and 2009 in two row plots. The rows were 3 m long, 90 cm apart and there was a space of about 6 cm between two plants in a row. linolenic acid of 125 RILs were extracted and determined by gas chromatograph analysis[12].

1.3 Data analysis

All analysis was conducted through GGE biplot[13].

2 Results and analysis

2.1 Genetic parameter analysis

Phenotypic values of linolenic acid content of 125 recombinant intercross lines across 3 environments were showed in Table 1. Difference of linolenic acid content between parents was obvious; however, the differences among those 125 lines weren't significant across three tested environments.

Table 1 Statistical analysis of linolenic acid content of RIL at different environments

Environments	Parents		Recombinant intercross line			
	Hefeng 25	Dongnong L-5	Range	means	SD^b	CV
2007 Harbin	5.56	2.32	2.53-7.71	5.10	1.36	0.27
2008 Harbin	5.77	2.81	2.61-5.46	4.17	0.75	0.18
2009 Harbin	7.25	2.56	2.60-5.99	4.41	0.86	0.19

2.2 Mean performance and stability of the genotypes across locations

Location attributed higher proportion of the variation in the data (35%), while genotype contributed to 60% of total variation. Genotype × location interaction contributed only 5% of total variation. Line P63 was the best performing genotype for LN content across three different environments, on the other hand, Line P38 was the poorest among those 125 lines.

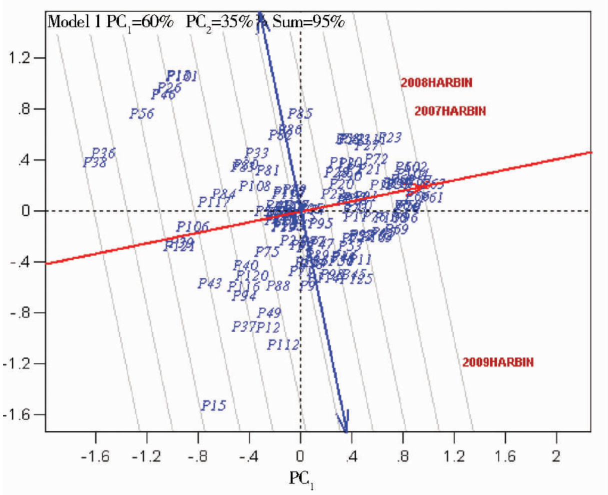

Fig. 1 Perform of linolenic acid content of 125 lines

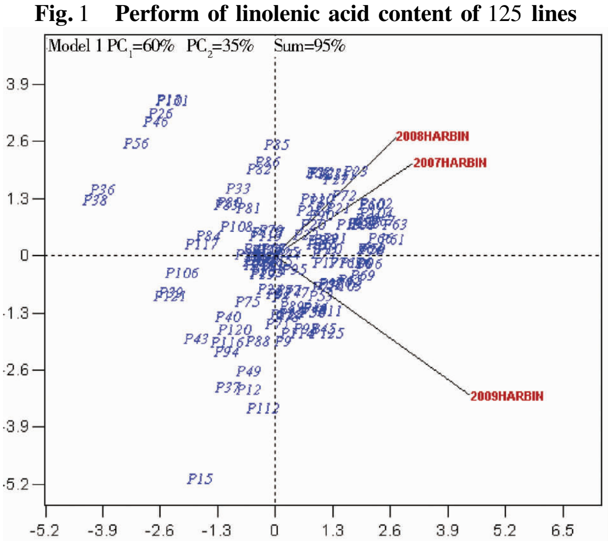

Fig. 2 Analysis of relatedness among different environments

2.3 Environment evaluation

The angles between different environments indicated that those three location were highly correlated (Fig. 2). Environments vector length showed variation of genotype was caused by environments, which suggested that variation by Harbin in 2009 was higher than that of other two environments. Fig. 3 indicated Harbin in 2009 was the closest to the average environment followed by Harbin in 2007 and Harbin in 2008.

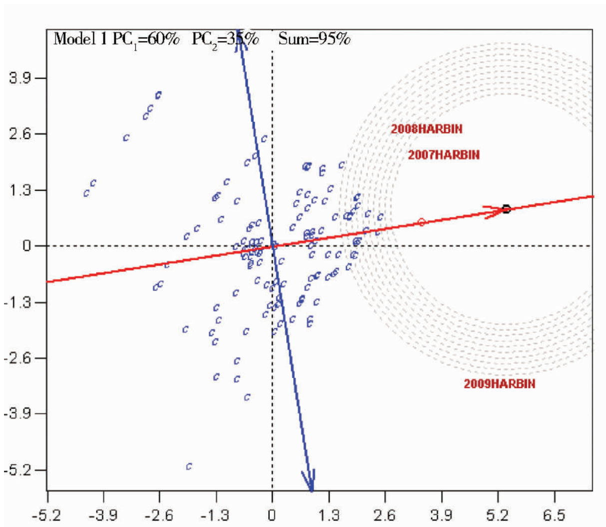

Fig. 3 Ranking of environment based on discriminating ability and representativeness

2.4 Ideal genotype analysis

Fig. 4 showed the ranking of the genotypes for LN content in terms of 'ideal genotype'. From our study it may be stated that line P63 was closed to ideal genotypes.

2.5 Which-won-where and mega-environment identification

The performances of LN content of 125 lines on each tested environment were evaluated. With the environment linked to line P63, P23, P101, P38, P15, and P125 as the corner genotype, Harbin in 2007 and Harbin in 2008 fell into the sector in which P63 was the most stable genotype for the three environments (Fig. 5), and line P25 was the best genotype for Harbin in 2009, However, P101, P38 and P15 were the poorest for any environment (Fig. 5).

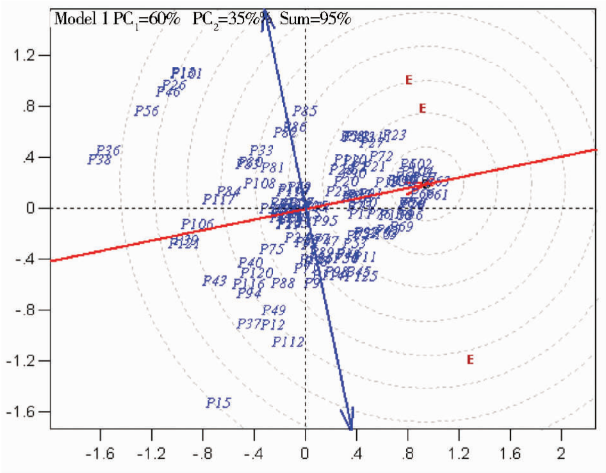

Fig. 4 Ranking of genotypes relative to an ideal genotype (the small circleon average environment coordinate, AEC)

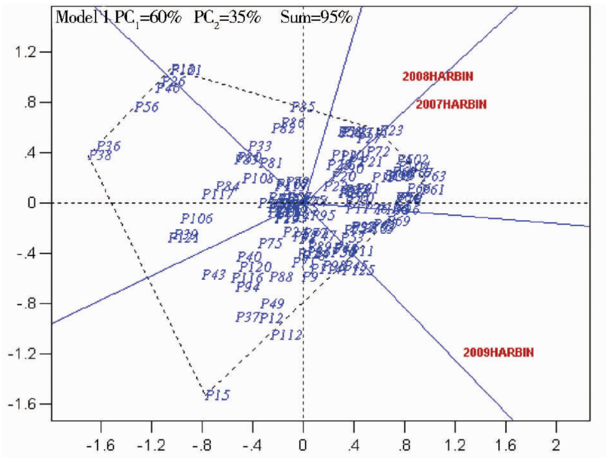

Fig. 5 Five linolenic acids perform in different environments

3 Conclusion and discussion

It is known that polyunsaturated fatty acids are not desirable for human consumption since they became rancid in a short time. Decreases in linolenic acid makes the oil better for human consumption. Fatty acid concentration can be manipulated in a breeding program if the evaluations of the trait are well known and desired sources of germplasm are available. Several genes have been discovered that alter FA content considerably. Some genes are naturally occurring, and others were produced through mutation[14]. It has been suggested that there are modifying genes along with the major FA genes that affect the different FA levels[15]. It is known that fatty acid composition is a quantitative trait[16]. These modifier genes have small effects that cause the FA profiles of populations to act as a quantitative trait. Moreover, FA, especially LN content, was significantly affected by environments. GE interaction significantly effected LN performs of different genotype. The higher the GE interaction, the lower stability among genotypes for their different responses to environments. Hence, effective method, used to evaluate of LN content, was important to select a line with appropriate LN content. GGE biplot offered an effective mean to evaluate genotype perform across multi-environments[13], which could effectively rank the stability of genotype, and identify ‘which won-where’ among the tested locations[8]. In the present study, mean performance and stability of LN of the RIL across locations was evaluated, the results showed that P63 and P25 were super genotypes for Harbin in 2007 and 2008, and Harbin in 2009, respectively. Among these tested RIL, P63 had good linolenic acid stability performance among all genotypes.

‘Ideal genotype’ was the goal of soybean breeder, which was defined by the greatest vector length of the stable genotype with zero GE interaction as located at the center of the concentric circles in Fig. 4. Genotypes located closer to the ‘ideal genotype’ are more stable than others. P63 was closed to ideal genotypes. In the present study, most genotypes varied with different tested environments, thus, selecting genotype with stable performance was important for developing new cultivars across multi-environments.

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