STABILITY OF YIELD AND OTHER CHARACTERS OF SUNFLOWER ACROSS ENVIRONMENTS

Chutamard Piasai[1,*] and Paisan Laosuwan[2]

Received: Aug 26, 2010; Revised: Dec 7, 2010; Accepted: Dec 13, 2010

Abstract

Ten synthetic varieties of sunflower and 2 check hybrids were tested in 7 environments in Nakhon Ratchasima province in 2003-2005 by using a randomized complete block design . The highest yield was exhibited by Pioneer, a hybrid, with the yield of 438 kg rai^{-1}. The performance of the synthetic varieties, LOC, CM1, LOO, and HOO which yielded 372, 362, 351, and 344 kg rai^{-1}, respectively, were not significantly different from Pacific 44, another hybrid check. The pooled analysis of variance showed that varieties-environment interactions (VxE) were significant for seed yield, plant height, disk size, and seed size. The regression analysis was used to partition VxE interaction into linear and non-linear components. The stability parameters (bi and S^2di) showed that 10 varieties were stable for yield, 7 varieties for plant height, none for disk size, and 10 varieties for seed size. The stability parameters for seed yield of individual varieties showed that, for synthetic varieties, LOC, CM1, LOO, and HOO with above average seed yield were stable and could be recommended for general production.

Keywords: Sunflower, *Helianthus annuus* L., stability, synthetic variety

Introduction

During the past decade, sunflower production has become popular in Thailand, especially in the lower central part of the country in Lop Buri, Saraburi, and Nakhon Ratchasima. All the seeds being grown by farmers are imported hybrids and the cost is high ranging from 250-350 Baht kg^{-1}. The hybrid seed production business for sunflower has not been established in Thailand and many synthetic varieties were developed to be used as stop-gap varieties. These varieties should give a similar yield as well as oil content to hybrid varieties.

Improvement of complex traits, such as yield of crops, which are strongly influenced by environments should be evaluated in many environments. Data obtained from those tested are used to identify genotypes or varieties that perform well across environments. Many techniques have been developed to evaluate the stability of crop varieties or lines over a

[1] *School of Crop Production Technology, Suranaree University of Technology, 111 University Avenue, Muang District, Nakhon Ratchasima 30000, Thailand. E-mail: chpiasai@hotmail.com*

[2] *Faculty of Science and Technology, Hatyai University, Hat Yai, Songkhla 90110. Thailand*

[*] *Corresponding author*

range of environments. The regression method developed by Yates and Cochron (1938) provides the main basis of this type of study. The method was later modified by Finlay and Wilkinson (1963) and refined by Eberhart and Russell (1966) and Perkins and Jinks (1968). The method which does not use the regression of crop performance on environments but uses the conventional coefficient of variation (CV%) was developed by Francis and Kannenberg (1978)

The purposes of this study were to evaluate the performance of synthetic varieties of sunflower for yield and other characters and to determine their stability over a set of environments by using the regression method of Eberhart and Russell (1966).

Materials and Method

In this study, 10 synthetic varieties and 2 hybrid checks of sunflower were tested in 2 locations in Nakhon Ratchasima Province during 2003-2005. These sunflower varieties are shown in Table 1. The tested locations were SUT (Suranaree University of Technology) Farm and NCSRC (National Corn and Sorghum Research Center). In these stations, the test was made for 4 and 3 seasons, respectively, making 7 environments in all. The experiments were conducted in a randomized complete block design with 4 replications. For each plot, 5 rows each 6 m in length were used with spacings of 75 cm between rows and 25 cm between plants within rows. At planting, chemical fertilize formula 15-15-15 N, P_2O_5, and K_2O was drilled in to the rows at the rate of 25 kg rai^{-1}. After planting, conventional cultural practices for this crop were applied when required. Supplementary irrigation was made when there was a shortage of rainfall or in the dry season. Before flowering, an additional 25 kg rai^{-1} of NPK fertilizer was applied. The measurements of characters were made as follows:

Seed yield: Three central rows were harvested to estimate yield. Before harvest, the ended plants at both ends of each row were trimmed to eliminate the bias of yield estimation. The yield was recorded at 12% moisture content in kilogram per rai (1 rai = 0.16 ha)

Table 1. Types and sources of varieties used in study

No.	Variety	Type	Source [1]
1	High Oil Cross (HOC)	Synthetic variety (Syn)	SUT
2	High Oil Open (HOO)	Syn	SUT
3	Medium Oil Cross (MOC)	Syn	SUT
4	Medium Oil Open (MOO)	Syn	SUT
5	Low Oil Cross (LOC)	Syn	SUT
6	Low Oil Open (LOO)	Syn	SUT
7	Diallel 1	Syn	SUT
8	Suranaree 471 (S. 471)	Syn	SUT
9	Suranaree 473 (S. 473)	Syn	SUT
10	Chiangmai 1 (CM1)	Syn	DOA
11	Pioneer	Hybrid	PHB
12	Pacific 44	Hybrid	PSC

[1] *Sources : SUT = Suranaree University of Technology, DOA = Department of Agriculture, PHB = Pioneer Hi-Bred International, Inc., PSC = Pacific International Seed Company, Inc.*

Plant height: The average of stem length in centimeter of the 10 randomly selected plants in each plot measured from the ground level to the top of the plant just beneath the disk flower.

Disk size: The disk size of each plot was the average in centimeter of 10 randomly selected disks measured before harvest.

Seed size: Seed size was recorded in grams per 100 seeds. Three samples of 100 seeds each were taken from each plot. The mean of the 3 samples was used as the representative of seed size of each plot.

Data of all characters were considered, followed, and analysed according to the random model (Model II). Before the combined analyses of variance were performed, the data for each character obtained from individual environments were analysed separately and their error variances were used to test for homogeneity according to the method suggested by Bartlett (1937). When the interaction of variety × environment (VxE) was presented, parameters of varietal stability were computed using the regression approach of Eberhart and Russell (1966).

Results and Discussion

Highly significant differences ($P < 0.01$) among environments and varieties were shown for seed yield, plant height, disk size, and seed size, indicating the difference in the performance among varieties for these characters as well as the environments under which the experiments were conducted (Table 2). The significances of V × E were found for all characters.

Means over all environments for seed yield, plant height, disk size, and seed size are shown in Table 3. Two hybrid varieties, Pioneer and Pacific 44, included as checks yielded 438 and 371 kg rai^{-1}, respectively. Yield of synthetic varieties ranged from a low of 312 kg rai^{-1} for S. 473 to a high of 372 kg rai^{-1} for LOC. LOC gave the highest yield for synthetic varieties (372 kg rai^{-1}) which was similar to Pacific 44, one of the most widely grown varieties in the country. CM1, LOO, and HOO which yielded 362, 351, and 344 kg rai^{-1}, respectively, were also not significantly different from Pacific 44. High variation also was found for plant height. S. 473 was the shortest at 159 cm in height while CM1 was the tallest at 180 cm. Pacific 44 gave the largest disk while that at S. 473 was the smallest. For seed size, CM 1 gave the largest and S. 473 the smallest. These characters including seed yield, plant height, disk size, and seed size of some synthetic varieties were comparable to the checks, especially Pacific 44 which is being planted widely by farmers.

Table 2. Mean squares obtained from analysis of variance and F-test for significances of 12 sunflower varieties tested across 7 environments

Sources of variation	df	Seed yield	Plant height	Disk size	Seed size
Varieties (V)	11	33,407.39**	2,101.34**	8.87*	1.93**
Environments (E)	6	536,134.01**	15,756.01**	74.16**	78.16**
V × E	66	8,499.14**	282.34**	1.60*	810,431.33**
Environment (Linear)	11	23,636.51**	112.28*	0.67**	117.24*
V × E (Linear)	1	4,143.05**	88.19^{ns}	0.24^{ns}	0.19^{ns}
Pooled deviation	66	1,506.99^{ns}	61.47**	0.40**	0.14^{ns}
Pooled error	252	1,206.36	27.94	0.04	0.14

*,**, *ns = significantly different at 0.05, 0.01 levels, and not significant, respectively.*

This should make these varieties acceptable to farmers around the area where they were tested.

Analysis of variance in Table 2 showed the significant difference of V × E interaction of all characters in this study. Therefore, the V × E interactions were further partitioned into linear and non-linear (pooled deviation) components, according to the method described by Eberhart and Russell (1966), as are shown in Table 2. The contribution of the linear components was significant for seed size ($P < 0.01$) but not for plant height, disk size, and seed size. The V × E interaction was regulated by the linear component for seed yield, indicating that the prediction of this character can be made across environments. On the other hand, non-linear components were important for plant height and disk size as shown by the significant different at $P < 0.01$. This indicated that these characters were non-predictive.

The stability parameters of each character for the 12 varieties are shown in Table 4. Seed yield is the most important trait in this study. The stability analysis for this trait showed that 10 varieties, except HOC and MOC, were stable and had predictable performance. Three synthetic varieties, LOC, LOO, and HOO, which gave higher seed yield than the mean of synthetic varieties (338 kg rai^{-1}) exhibited respective regression coefficients of $b_i = 1.10$, 1.15, and 0.99 and their S^2_{di} were not significantly different from zero indicating that they could be used for general cultivation. Other varieties, such as CM1 and Pioneer giving respectively $b_i = 1.24$ and 1.27, should be grown in good environments. On the other hand, HOC, with $b_i = 0.60$, should be planted in poor environments.

The stability analysis for plant height showed the non-significant differences of regression coefficients of all varieties from unity, but only 7 varieties were stable as their

Table 3. Means for seed yield, plant height, disk size and seed size, of sunflower varieties tested in 7 environments

Variety	Seed yield (kg rai^{-1})	Plant height (cm)	Disk size (cm)	Seed size (g/100 seeds)
HOC	339^{bcde}	173^{cd}	15.93^{ab}	5.47^{bc}
HOO	344^{bcde}	166^{e}	15.47^{bcd}	5.53^{b}
MOC	312^{e}	168de	15.41^{bcd}	5.21^{bcd}
MOO	330^{cde}	167^{e}	15.11^{de}	5.22^{bcd}
LOC	372^{b}	174^{ee}	15.83^{ab}	5.33^{bcc}
LOO	351^{bcd}	176^{bc}	15.87^{ab}	5.33^{bc}
Diallel 1	324de	170de	15.25^{cd}	5.15^{cd}
S. 471	333^{cde}	167^{e}	14.91^{de}	4.99^{de}
S. 473	312^{e}	159^{f}	14.59^{e}	4.85^{e}
CM 1	362^{bc}	180^{b}	15.06^{de}	5.88^{a}
Pioneer	438^{a}	197^{a}	16.40^{a}	5.28^{bcd}
Pacific 44	371^{b}	175^{bc}	16.31^{a}	5.22^{bcd}

(1) *Means in each column followed by the same letters are not significantly different according to Duncan Multiple Range Test at P = 0.05.*

Table 4. Stability parameters of seed yield, plant height, disk size, and seed size of 12 varieties of sunflower grown in 7 environments

Varieties	Yield			Plant height			Disk size			Seed size		
	Mean[(1)] (kg rai^{-1})	b^i	S^2_{di}	Mean (cm)	b^i	S^2_{di}	Mean (cm)	b^i	S^2_{di} (g/100 seeds)	Mean	b^i	S^2_{di}
HOC	339	0.60	3486**	173	1.12	88**	15.93	1.39*	-0.18**	5.47	1.00	-0.04
HOO	344	0.99	-620	166	0.81	54**	15.47	1.08	-0.14**	5.53	0.99	-0.03
MOC	312	0.47*	814	168	1.15	9	15.41	0.90	0.47**	5.21	0.81	-0.01
MOO	330	0.88	831	167	1.04	20	15.11	0.94	-0.15**	5.22	0.87	0.09
LOC	372	1.10	-113	174	1.15	7	15.83	0.90	0.12**	5.33	0.99	0.32**
LOO	351	1.15	-661	176	1.24	6	15.87	0.92	-0.00**	5.33	1.14	-0.02
Diallel 1	324	1.17	-542	170	1.18	10	15.25	1.10	-0.15**	5.15	0.93	-0.08
S. 471	333	1.11	-518	167	0.90	22	14.91	0.65	0.50**	4.99	1.08	0.09
S. 473	312	1.10	146	159	0.75	69	14.59	1.04	0.30**	4.85	1.11	0.03
CM 1	362	1.24	563	180	0.75	4	15.06	1.10	0.21**	5.88	1.29	0.04
Pioneer	438	1.27	147	194	0.67	41	16.40	0.97	-0.21**	5.28	0.97	0.02
Pacific 44	371	0.90	74	175	1.25	73	16.31	0.95	0.05**	5.22	0.81	0.15**

(1) *1 rai = 0.16 ha.*

values were S^2_{di} significantly different from zero. For disk size, all varieties accept HOC exhibited regression coefficients not different from unity, but all were not stable due to their significant S^2_{di} values. All varieties gave non-significant from unity of regression coefficients for seed size but two varieties, LOC and Pacific 44, were not stable for these characters.

Conclusions

This study gave very promising results that synthetic varieties developed in Thailand, including CM 1 by the Department of Agriculture (Kaewmeechai *et al*., 1990) and LOC, LOO, and HOO by Suranaree University of Technology, can be used for general production. Although their yield potential was inferior to hybrids, farmers can produce their own seed. From the laboratory analysis, CM1 gave a little bit of a low oil content, but that of LOC, LOO, and HOO is comparable to hybrids. (Laosuwan and Machikowa, 2007). The regression method of Eberhart and Russell (1966) was used to determine the stability of sunflower for yield and other characters. The stability parameters showed that 10 varieties were stable for yield and seed size, 7 varieties for plant height, and none for disk size. Four synthetic varieties including LOC, CMI, LOO, and HOO which gave promising seed yield were also found to be stable for this character.

Acknowledgements

The authors gratefully acknowledge the kind assistance of the Thailand Research Fund (TRF) for providing funds that make this research work possible.

References

Bartlett, M.S. (1973). Some examples of statistical methods of research in agriculture and applied biology. J.R. Stat. Soc. Supp., 4:137-183.

Eberhart, S.A. and Russell, W.L. (1966). Stability parameters for comparing varieties. Crop Sci., 6:36-40.

Finlay, K.W. and Wilkinson, G.M. (1963). The analysis of adaptation in a plant-breeding programme. Aust. J. Agric. Res., 14:742-754.

Francis, T.R. and Kannenberg, L.W. (1978). Yield stability studies in short-season maize I. A descriptive method for grouping genotypes. Can. J. Plant Sci., 38:1029-1034.

Kaewmeechai, S., Na Lampang, A., Potan, N., Dangpradub, S., Kachonmalee, V., and Pumklom, M. (1990). Production of synthetic sunflower varieties. Oilseed Crops Development Project Research Report for 1989, p. 10-14.

Laosuwan, P. and Machikowa, T. (2007). Breeding of synthetic varieties of sunflower for high oil content. SUT-TRF Sunflower Breeding Project Final Report, p. 49-61.

Perkins, J.M. and Jinks, J.L. (1968). Environmental and genotype-environmental components of variability. III Multiple lines and crosses. Heredity, 23:339-356.

Yates, F. and Cochran, W.G. (1938). The analysis of groups of experiments. J. Agric. Sci., 28:556-580.