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Combining Ability of Yield and Yield Components in Pickling Cucumber

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ABSTRACT

Combining abilities of fruit yield per plant, number of fruits per plant and flesh thickness were studied using 2 local and 3 introduced pickling cucumber varieties. Diallel crossing was done to produce 20 F1-hybrids - 10 direct crosses and 10 reciprocal crosses. The hybrids and parents were grown in a 5 × 5 simple lattice manner. Data analysis revealed significant difference among genotypes in all characters, while reciprocal effect was significant in number of fruits per plant and flesh thickness. Non-additive gene effect was found to control yield per plant, whereas both additive and non-additive effect were equally important in conditioning number of fruits per plant and flesh thickness.

' Taiwan Variety ' was identified as a good source of genes for more fruits per plant and thicker flesh. The cross between Thai cucumber ' Flying Boy ' and the above variety expressed high number of fruits per plant and thus should be chosen for inbred line source and hybrid production. In this study, flesh thickness and number of fruits per plant expressed significant positive effect on fruit yield per plant.

INTRODUCTION

Cucumber *(Cucumis sativus* L. *)* in Thailand is largely consumed in two types, table and pickling. The table type varieties have thicker flesh than the pickling ones. Although hybrid cucumbers are available in the market, most farmers still keep seeds of the traditional cultivars. As Thailand started exporting pickling cucumber, the use of hybrid varieties would upgrade yield and quality of the product. Under large scale production, hybrid cucumber can be harvested by machine. The rising labor cost also forces farmers to grow uniform hybrid to facilitate cultural practices and harvesting. Development of hybrid cucumber in Thailand is still at the infant stage. Up till now no information is available regarding combining abilities between local and introduced cucumber cultivars. All hybrids are introduced from overseas by seed companies. To stand on her own, Thailand must start compiling information pertaining to hybrid development from locally available materials. This presentation revealed heterosis and combining ability of 5 high yielding pickling cucumber varieties available in Thailand.

Heterosis, combining ability and hybrid seed production of cucumber were reviewed by Peterson and Welgle (1958) for germplasm available in the US. In 1963 Peterson and Dezeeuw reported that hybrid pickling cucumber ' Spartan Dawn' expressed high heterosis in resistance to mosaic virus and scab, early maturity, high yield and produced high quality pickles. Later, Ponti (1972) reported that F_1 cucumber showed

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hybrid vigor in most desirable traits. Chankrachang (1984) made all possible crosses between 5 local Thai cucumbers and found that the F_1-progenies were superior to parents in all traits, except fruit weight per plant and number of fruits per plant. Yield per plant, number of fruits per plant, flesh thickness, fruit shape index, harvesting date and internodal length were found conditioned by both additive and non-additive gene action. He suggested that the cucumber population be improved through prolificacy and flesh thickness.

The current investigation aimed at combining ability study among 3 local and 2 commercially introduced cultivars. The information should serve as a guide-line for further improvement of these genotypes as well as for employment of desirable genes existing in them.

MATERIALS AND METHODS

Five diverse cucumbers were employed in this study. Two inbreds were extracted from local cultivars ' Seven Leaves ' and ' Small Fruits ' by Pak Chong Agricultural Research Station of Kasetsart University. An open-pollinated ' Flying Boy ' and ' Taiwan Variety ' were introduced by the Suco Agro. Co. Ltd. in Thailand. The last genotype was ' Asgrow # 1 ' from the Asgrow Seed Co.Ltd., which was proven to be well adapted to Thailand condition. The five cucumbers were crossed in all combinations to form 20 F_1's having 10 direct and 10 reciprocal crosses. The F_1's and parents were grown in a 5 × 5 simple lattice design having 25 plants per plot but data were collected from only 12 plants. The seeds were sown in 50 × 75 cm spacing. The 15-15-15 fertilizer was basally applied in row at the rate of 50 kg/rai. At 30 and 46 days after seeding a 13-13-21 fertilizer was side-dressed at 30 kg/rai. Pesticides were sprayed every 2 weeks. Fruits were picked at 4 to 5 days after flowering or when fruit size was less than 12 cm long and 2 to 3 cm in diameter. Data on fruit yield per plant, number of fruits per plant and flesh thickness were recorded along with several other traits. However, only the said 3 traits were reported herewith.

The experiment was conducted at Orapin Farm, Hang Dong District, Chiang Mai Province.

Data of each trait were analyzed in a simple lattice manner as outlined by Cochran and Cox (1968). Once treatment difference was declared, the reciprocal effect would be measured. If the effect was not significant, data from direct and reciprocal crosses were combined as one data set. If significance was detected, however, the 2 data sets were kept seperated. The data were analyzed further using variety cross diallel method-analysis II as advocated by Gardner and Eberhart (1966). The parameters to be estimated were as followed.

u_v = parental average

v_j = effect of the j^{th} line, comprising both additive and non-additive gene action

$\bar{h}$ = average heterosis of all F1-progenies

h_j = heterosis of the j^{th} line measured as deviation from $\bar{h}$ ($\Sigma h_j = 0$)

$s_{jj'}$ = specific heterosis of the F1 derived from the cross between the j^{th} and the j'^{th} line ($\Sigma s_{jj'} = \Sigma s_{j'j} = 0$)

The parameters were estimated from the observed data and reconstructed into 4 data sets, each according to 4 models as followed.

Model 1 : $Y_{jj'} = u_v + 1/2 (v_j + v_{j'})$

Model 2 : $Y_{jj'} = u_v + 1/2 (v_j + v_{j'}) + r\bar{h}$

Model 3 : $Y_{jj'} = u_v + 1/2 (v_j + v_{j'}) + r\bar{h} + r (h_j + h_{j'})$

Model 4 : $Y_{jj'} = u_v + 1/2 (v_j + v_{j'}) + r\bar{h} + r (h_j + h_{j'}) + rs_{jj'}$

While r = o when j = j' and r = 1 when j ≠ j'

$$h_{jj'} = \bar{h} + h_j + h_{j'} + s_{jj'}$$

$h_{jj'}$ is a combined heterosis of the F1 from j^{th} and j'^{th} lines.

Data reconstructed according to each model were computed for sum of squares and assigned the symbol BG_1 to BG_4. Variation due to each added parameter was obtained through subtraction between 2 BG_i's having different number of parameters as shown in Table 1.

RESULTS AND DISCUSSION

Analysis of variance of yield per plant in 20 F_1-progenies and 5 parents revealed significant difference. The reciprocal effect was not different as shown in Table 2. Thus data from direct and reciprocal crosses were combined and analyzed for variation due to important parameters as in Table 3. The combined means were presented in Table 4. Average heterosis was the only significant contributor to the difference in yield per plant. As one can see from Table 4 that the F_1's (upper diagonal figures) were relatively higher than parents (diagonal). The results agreed with those reported by Om *et al.* (1978) who employed a half-diallel analysis of 7 cucumber lines and found significant heterotic effect on this trait.

Number of fruits per plant in this study was significant among the tested entries (Table 2). The reciprocal effect was also significant, indicating that maternal effect might play roles in controlling this trait. Thus data from direct and reciprocal crosses were kept seperate for subsequent analyses. Average number of fruits per plant was given in Table 5. The genetic contribution of various estimated parameters, according to Gardner and Eberhart (1966), was presented in Table 3. Heterosis played important role in treatment difference, revealing that non-additive gene effect was a major contributor to genetic variation of this trait. This results agreed well with the report by Om *et al.* (1978) and Airapetyan (1981). Yet additive gene action could not be omitted, as significant variety component (v_j) revealed importance of both additive and non-additive gene effect.

A similar result was found in flesh thickness where reciprocal effect was significant (Table 2). Thus analysis was performed in the same manner as of number of fruits per plant. Flesh thickness varied from .55 to .79 cm with clear specific combining ability and reciprocal effect in certain crosses (Table 6). For example, direct cross between Seven Leaves and Small Fruits gave the average flesh thickness of .56 cm while the reciprocal F_1 gave .70 cm thick. On the average, the direct cross F_1 had thinner flesh than parents while the reciprocal F_1 was not different from the parents. This result agreed with earlier report by Chankrachang (1984) who found maternal effect in flesh thickness of local cucumbers. This was confirmed in the diallel analysis in Table 3. Since the variety component (v_j) had significant effect on both direct and reciprocal crosses, therefore gene actions governing flesh thickness were of both additive and non-additive type. The result was similar to what mentioned by Poole (1962) who found that flesh thickness was governed by genes with mostly of dominant action.

Positive correlation was detected between yield per plant and number of fruits per plant (r = .351) and between yield per plant and flesh thickness (r = .488) at 23 df. Thus yield and yield components in this study can be handled together in a selection program. In this study gene action controlling yield per plant *per se* was not as prominent as that of number of fruits per plant and flesh thickness. Considering this, the plant breeder would be able to utilize both

Table 1 Analysis II of variety cross sum of squares according to Gardner and Eberhart (1966).

Source of variation	df	SS
Population	[n(n-1)/2] -1	$S = BG_4 - CF$
Lines (v_j)	n - 1	$S_1 = BG_1 - CF$
Heterosis ($h_{jj'}$)	n (n-1)/2	$S_2 = BG_4 - BG_1$
Average ($\bar{h}$)	1	$S_{21} = BG_2 - BG_1$
Variety (h_j)	n - 1	$S_{22} = BG_3 - BG_2$
Specific ($s_{jj'}$)	n (n-3)/2	$S_{23} = BG_4 - BG_3$

Where n = number of parental lines.

Significance of each parameter was declared against pooled error.

Table 2 Analysis of variance of fruit yield per plant (kg), number of fruits per plant and flesh thickness of 20 F_1 - hybrids and 5 parental lines of pickling cucumber.

Source of variation	df	MS		
		Fruit yield	No. of fruits	Flesh thickness
Replications	1	.004	3.6	.013**
Treatments	24	.128*	18.37**	.007**
Reciprocals	10	.06	8.98**	.005**
Residuals	14	.17	25.08	.008
Error	24	.058	2.04	.001
CV (%)		36.10	10.48	13.36

*,** Significant at .05 and .01 level of probability, respectively.

Table 3 Combining ability of yield per plant, number of fruits per plant and flesh thickness in 10 F_1 – hybrids and 5 parental lines of pickling cucumber. Data were analyzed using variety cross diallel method-analysis II (Gardner and Eberhart, 1966).

Source of variation	df	MS				
		Fruit yield	No. of fruits		Flesh thickness	
			Direct	Recip.	Direct	Recip.
Treatments	14	.05	10.57**	10.74**	.005**	.003**
Varieties (v_j)	4	.08	21.13**	14.15**	.01**	.005**
Heterosis ($h_{jj'}$)	10	.04	6.35**	9.37**	.002	.001
Average ($\bar{h}$)	1	.17*	0.71	2.98	.008**	.001
Variety (h_j)	4	.05	12.65**	16.53**	.002	.002
Specific ($s_{jj'}$)	5	.004	2.44	4.92	.001	.001

*,** Significant at .05 and .01 level of probability, respectively.

Table 4 Fruit yield per plant (kg) of 10 F_1-hybrids (reciprocals combined) and 5 parental lines (diagonal) of pickling cucumber.

Lines	Seven Leaves	Small Fruits	Flying Boy	Taiwan Var.	Asgrow # 1
Seven Leaves	**0.38**	0.54	0.53	0.95	0.72
Small Fruits		**0.41**	0.37	1.00	0.56
Flying Boy			**0.49**	1.02	0.60
Taiwan Var.				**0.67**	0.89
Asgrow # 1					**0.63**

Table 5 Number of fruits per plant of 10 direct cross F_1-hybrids (upper diagonal), 10 reciprocal cross F-hybrids (lower diagonal) and 5 parental lines (diagonal) of pickling cucumber.

Lines	Seven Leaves	Small Fruits	Flying Boy	Taiwan Var.	Asgrow # 1
Seven Leaves	**4.10**	5.65	4.05	8.65	6.05
Small Fruits	6.10	**9.00**	11.45	10.95	6.85
Flying Boy	9.90	4.85	**15.70**	12.30	9.10
Taiwan Var.	10.00	12.90	13.65	**6.25**	10.45
Asgrow # 1	6.95	8.25	8.20	9.55	**5.80**

Table 6 Flesh thickness (cm) of 10 direct cross F_1-hybrids (upper diagonal), 10 reciprocal cross F_1-hybrids (lower diagonal), and 5 parental lines (diagonal) of pickling cucumber.

Lines	Seven Leaves	Small Fruits	Flying Boy	Taiwan Var.	Asgrow # 1
Seven Leaves	**.60**	.56	.55	.70	.71
Small Fruits	.70	**.65**	.61	.66	.68
Flying Boy	.68	.62	**.69**	.65	.68
Taiwan Var.	.67	.68	.71	**.79**	.73
Asgrow # 1	.67	.63	.67	.73	**.76**

additive and non-additive genes prevailing in the parental lines. A recurrent selection scheme could be set to optimize most additive genes conditioning the yield components and, at the same time, improve yield per plant through their positive relationship. However, if one wanted to capitalize non - additive gene through hybrid development, specific combining abilities were noticed in some crosses. For example, F_1 of the cross between Taiwan Variety and Flying Boy displayed high number of fruits per plant. Since these 2 varieties were not inbred, one would need to extract certain inbred lines to be tested for appropriate hybrid combinations before further use.

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