Breeding of Powdery Mildew Resistant Squash 'Miso'

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Abstract

A new powdery mildew resistant squash (Cucurbita moschata Duch.) 'Miso' was bred from a cross between powdery mildew resistant true variety 'Sangol' and powdery mildew susceptible inbred line 'Seoulmadi' at National Institute of Horticultural & Herbal Science (NIHHS). The 'Miso' variety was vigorous and highly resistant to powdery mildew. It showed white green fruit color. The variety yielded 21.3MT/ha which is 52% more than control variety.

Introduction

Powdery mildew disease is frequently found in fields of Cucurbit crops. The causal agents of this disease are reported as *Erysiphe cichoracearum* DC ex. Merat and *Sphaerotheca fuliginea* (Schlecht ex.Fr) Poll. (Sitterly, 1978). In Korea, powdery mildew is caused by 13 types of fungi such as *Sphaerotheca, Erysiphe, Blumeria, Golovinomyces, Leveillula, Phyllactinia* etc. and is know to damage around 300 plant species (Korean Society of Plant Pathology, 2004; Shin, 1994b). Powdery mildew (*Sphaerotheca fuliginea*) is a most important disease of squash and difficult to control on squash, cucumber, oriental melon, melon and other cucurbit plants (Cho et al., 2004, Kim, 1999; Ma et al., 2003). The excessive use of pesticide for control of powdery mildew has led to pesticide resistance of the pathogen and reduction of pesticide efficacy (Asari et al. 1994; Erickson et al., 1997; Lyr et al. 1996). In addition the importance of developing pesticide-free approaches to powdery mildew control is emphasized by the negative effects of irresponsibly applied pesticides on human health and environment. To control powdery mildew efficiently, it is desirable to introduce resistance from wild type into cultivated cultivars. The objectives of this study are (Ⅰ) to develop powdery mildew resistance F_1 hybrid variety that shows high quality and quantity (using mentioned above inbred lines) and (Ⅱ) to provide commercial F_1 hybrid variety for farmers (for squash production). Using powdery mildew resistant F_1 hybrids may contribute to eco-friendly control of the disease resulting stable production.

Materials and methods

The developed F_1 seeds were sown in the field on March 10, 2002 and the seedlings were transplanted at a planting density of 250×40㎝ in the vinyl house of National Institute of Horticultural & Herbal Science (NIHHS) on April 15. Each plot size is 2.5m×4.5m. The lines were cultivated at the experimental farm of NIHHS in Suwon, Korea, and were tested for F_1 combining abilities. The seed of selected combinations were resown on August 15, and the seedling transplanted under same cultivation conditions on September 10. The lines were cultivated in the unheated vinyl house before ambient temperatures started to go below freezing point, and were investigated

for some various traits, including yield, degree of resistance to powdery mildew and F_1 combining abilities. Management of the field experiment followed a non-pesticide approach but otherwise followed conventional practice. Resistance against powdery mildew was measured without artificial inoculation in field but relied on natural inoculum (Adeniji and Coyne, 1983). The disease severity index based on the lesion area of powdery mildew in leaf and stem were investigated and were classified into nine degrees, including 1 (non-disease symptom), 3 (less than 10% of leaf surface area), 5 (10 to 30%), 7(31 to 50%), and 9(51 to 100%). Powdery mildew incidence was measured five times for 10 plants at each plot in each season (Table 2). Each plot consisted of 10 plants and three replications. Degree of resistance was the percentage of diseased leaves and stem. Cultivation system was non organic cultivation system. The temperature from transplanting to harvesting ranged from 10 to 35℃ in spring and 5 to 28℃ in autumn. The sand-loam soil, pH and EC in the soil were maintained at 6.0~6.5 and 2.0 $dS.m^{-1}$, respectively. Statistical computations were carried out using the SAS v. 9.1(SAS Institute, Inc. USA) software. A randomized block design was used the experimental design with three replications. The experiment results were subjected to an analysis of variance(ANOVA). When significant differences were evaluated by t-test at the level of 5% range.

Results

To development of powdery mildew resistant squash cultivars, the F_1 lines were developed from the cross between the 'Jecheonjaerae' (an oriental type squash, collected in 1985 and fixed) and '*Cucurbita martinezii*' (a wild type squash with bitterness of fruit, introduced from Cornell university in 1990). The hybrids were crossed with 'Seoulmadi' (a green squash, collected in 1987 and fixed). Progenies in each generation were selected for resistance to powdery mildew and good fruit quality from the Backcross(BC) population were self-ferilized after the new hybrids were backcrossed to 'Seoulmadi'. Each year, we selected non bitterness fruits and highly resistant plants of powdery mildew. Through the selection progress, the two pure bred varieties, 'Sigol' and 'Sangol', were developed in 2001 (Cho et al. 2003). The selected lines were tested for F_1 combining ability during two cropping season, and then were selected as the F_1 variety of green squash. The final selected combination was designated as 'Miso'. Main characteristics of 'Miso' are significantly different from the commercial variety as shown in the Table 1; however, growth habit of 'Miso' was trailing. 'Miso' had number of female flowers slightly lower, leaf length and width slightly larger than 'Bulamsacheol'. Level of powdery mildew resistance in F_1 variety was higher than commercial varieties; the fruit shape is cylindrical with short in length and large in diameter. The fruit of fresh squash has whitish and green color and without neck that distinguished it from the control variety. The fruits of the developed variety turned yellow when ripening and were similar to those in commercial oriental squash varieties (Table 2). When compared with control variety 'Bulamsacheol', immature fruit of the developed variety, which had a mean fruit weight of 295g, length was 18.6cm, and diameter was 5.1 cm, was slightly heavier, shorter in length, wider in diameter. Developed variety had higher yield per ha than control variety because commercial variety plants were easy to be infected diseases at young stage and Table 3.

Table 1. Major morphological characteristics of a new oriental squash F_1 variety, "Miso"

Cultivar	Growth habit	Axillary branching[z](%)	Appearance of female flower(%)	Leaf length (cm)	Leaf width (cm)
Miso	Trailing	67 ± 5.8[y]	78 ± 4.7	17.5±2.5	23.0±3.4
Bulam-sacheol	Trailing	45 ± 4.3	85 ± 3.2	13.1±2.7	16.5±3.1

[z] Percentage of axillary branches and female flowers by the 20th nodes, respectively. Each characteristics value is 10 plants means per plot.
[Y] Data were the average of ten replications ± S.E

Table 2. Resistance to powdery mildew and the fruit characteristics of a new oriental squash F_1 hybrid, "Miso"

Cultivar	Degree of resistance[z]	Young fruit[y]			Surface color of ripe fruit	Bitterness
		Shape	Fruit color	Neck		
Miso	2	Cylindrical	Whitish and green	Absent	Yellow	No
Bulam-sacheol	9	Cylindrical	Whitish and green	Absent	Yellow	No

[z] Degree of resistance was calculated percentage of diseased leaves and stem from the ten investigated plants. Degree of resistance 1,3,5,7 and 9 with increasing severity.
[y] Harvested at 7 to 10 days after flowering.

Tabl e 3. Fruit yield of a new oriental squash variety, "Miso"

Cultivar	Young fruit [z]			Yield (kg/ha) [y]		
	Weight (g)	Length (cm)	Diameter (cm)	2003 Spring	2003 Autum	Mean
Miso	295±85	18.6±3.1	5.1±1.2	25,680 a[x]	16,830 a	21,260±625
Bulam-sacheol	267±81	19.2±2.7	4.6±0.8	15,660 b	12,400 b	13,880±165

[z] Harvested at 7 to 10days after flowering
[y] Characteristics of young fruit and yield were from 10 plants means per plots in spring and autum season of 2003. Spring season : April to July, Autum season : September to November. Data were the average of ten replications ± S.E
[x] Mean separation within columns by t-test at the level of 5% range.

Discussion

The powdery mildew is the most serious disease for the cultivation of squash in

Korea. Since no resistant variety is available, typical Korean farmers apply 9 to 10 times of pesticide to control the disease. Therefore, pesticide-safe production of squash in Korea has many obstacles should be avoided. To solve these problems, the development of resistant varieties is in demand. However, current Korean squash (*Cucurbita moschata*) shows no resistance against the disease. So, we tried to transfer the resistance from wild-type pumpkin (*Cucurbita martinezii*) to domestic one. Since newly developed variety showed relatively strong resistance against the disease, the use of chemical pesticide could be greatly reduced.

We suppose the genetic nature of resistant genes in the new variety is not single gene but one major gene with several minor genes (Cho et al., 2005). Also, we suggest the bitter taste of fruit and the resistance of powdery mildew are separately inherited. Therefore, we could developed the variety with no bitter taste and the disease resistance. But, the new variety has inferior morphological character of fruits against the susceptible varieties, and we need to improve this drawback. However, the newly developed variety, 'Miso' that has resistance on powdery mildew, can save the use of chemical pesticide below 10% of conventional one. Also the new one can yield more overall production amount with the resistance and good growth (Table 3).

Conclusions

The developed variety 'Miso', has shown strong resistance to powdery mildew. F_1 hybrid 'Miso' can be used also as powdery mildew resistance source for breeding by seed companies. Using powdery mildew resistant varieties, farmers will be able to reduce pesticide input, resulting in environmental, economic and health benefits.

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