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Composite–Sibbed Line Methods and Their Potential Use in Sweet Corn Hybrids

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ABSTRACT

The waxy, inbred line was crossed onto two inbred lines and one single cross of shrunken, super-sweet corn. They were then backcrossed onto the corresponding super-sweet parents. Following consecutive selfing up to BC_1S_4, 15 ears from each BC_1S_4 family were selected and then transformed into composite–sibbed lines by four different methods: consecutive selfing within family line (SFL), topcross within line (TCL), selective mass sibbing within line (MSL) and recurrent–sibbed line (RSL). Based on seed yield *per se* as the selection criterion, MSL and RSL were more effective than the other two methods. However, seed yield of the parent and the selection method did not imply the quality of fresh yield in the corresponding hybrid. Occasionally, some of the high seed yield lines from MSL and RSL not only gave high fresh-ear yield hybrids, but also an exceptional quality of fresh ears. The results reflected the possibility of using a composite–sibbed line method to improve the yield and quality of parent lines in sweet corn which could then be transmitted to the corresponding single cross hybrids.
Key words: sweet corn, composite line, hybrid

INTRODUCTION

Quality traits of sweet corn are decisive factors for the final selection of the commercial hybrid. Unfortunately, most quality traits are controlled by recessive genes which cause a reduction of plant vigor and increase the susceptiblility of the inbred to biotic and abiotic stresses. However, in certain circumstances, uniformity of the sweet corn product is of the utmost importance and therefore pure parent lines are needed for single cross hybrids, but such inbreds are weak and difficult to maintain. Generally, pedigree and backcross breeding are widely used for the improvement of inbred sweet corn. However, pedigree selection is suitable only for the detailed improvement of a few desirable traits of existing lines. It is also a time-consuming processes to bring several desirable traits from other lines into the new improved line, whereas backcross breeding is good only for the introgression of one or a few of the qualitative genes into the existing line with minimum changing of other quantitative traits, especially the yield ability of the line. Therefore, population improvement is recommended to supplement the gap in breeding material.

In normal corn where inbreeding depression is high, it is desirable to perform a few cycles of full–sib mass selection to accumulate desirable genes before conducting consecutive selfing, so that strong and high yield inbreds could

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be recovered (Lindstrom, 1939). In addition, where uniformity is not critical, selective mass sibbing within the S_1 line is suggested to prevent inbreeding depression in the derived line and hence maintain yield ability and the combining ability of the original S_1 line in later generations and such a line is referred to as a composite–sibbed line. With careful selection for uniformity of general appearance, such a line should be useful for the production of an early generation hybrid (Kinman, 1952). Empirically, alternate selfing and full sibbing in the F_2 population of a single cross not only increased the yield of the succeeding population, but also maximized the yield of individual full sib progeny as well (Genter, 1976). Therefore, instead of using such a method to improve the population as a whole, the method could be modified by grouping the S_1 lines into three S_1 lines per set and complete the cycle by a diallel full sib within the set. As a result, three F_1 full sibs are derived which will be selfed for the next selection cycle and bulk seed of F_1 of each cycle is referred to as the "Recurrent–Sibbed Line". The method has been proven to be a very effective method for the improvement of yield and uniformity of a composite–sibbed line in normal corn (Phuong *et al.*, 2007).

The present studies however, were set up to explore the possibility of transferring quality traits from waxy corn to a sweet corn line by four different methods of composite–sibbed line selections: consecutive selfing within the family line (SFL), topcross within line (TCL), selective mass sibbing within line (MSL), and recurrent–sibbed line (RSL). The effectiveness of the methods was evaluated by line performance *per se* as well as the usefulness of the corresponding hybrids.

MATERIALS AND METHODS

The waxy inbred line, Agwx – 11 was crossed onto super sweet corn inbreds; Agsh2-201, Agsh2-306; and a single cross, Agsh2-201/Agsh2-318 to transfer genes for pericarp tenderness and eating quality into super sweet lines. The resultant crosses were subsequently backcrossed onto the corresponding super-sweet lines and so three BC_1F_1 were obtained. They were self–pollinated and the resultant three BC_1S_1 families were then planted in a non–replicated honeycomb design (HC) having equilateral triangular plant-to-plant spacing of 0.866 m (Fasoulas and Fasoula,1995). After selfing, based on the general appearance of plant and ear characteristics supplemented with a bite test, 15 ears of BC_1S_2 for each family were selected. They were planted ear-to-row in HC and the best three plants in each row were selfed, bulked for two more consecutive generations and thereafter 15 ears of BC_1S_4 per family were selected, one from each row. Two sets of ear –to–row and one set of two rows-per-ear of the first five ears were planted in HC. In the first set, five composite–selfed family lines (SFL) were derived by selfing the three best plants in the row and the derived seed were bulked for the following consecutive selfing generation. In the second set, the best plant within each row was crossed onto the other three best plants within the same row and the derived line is referred to as topcross composite-sibbed line (TCL). In the third set, mass composite-sibbed lines (MSL) were derived from crossing the bulk pollens of the three best plants of row A with the three best plants of row B which came from the same ear. Two more of the remaining 10 BC_1S_4 ears were randomly added to each of the first five ears to form five sets of three ears/set and the best BC_1S_4 plant of each line was dialleled within the set to form three F_1 full sib lines. Subsequently, the best plant of each F_1 full sib line was selfed and the derived S_1 were dialleled in the following cycle and afterwards, the cycle was repeated. Bulk seeds of the three F_1 full sib lines of each cycle were referred to as "Recurrent–Sibbed Line" (RSL). This resulted in five composite-sibbed lines per method of selection, including four methods per family and thus with three families, a total of 60 lines were obtained.

All 60 derived lines were testcrossed onto composite–sibbed line 309, a super-sweet composite–sibbed line. Thereafter, the 60 composite–sibbed lines and their corresponding 60 testcross hybrids were separated in single row plots 5 m long and 0.75 × 0.30 m plant spacing with side–by–side checks at the ratio of 1:4 with four replications. All yield trials were planted in adjacent areas in the same block. Plot yield was calculated as suggested by Yates (1936) before being analysed statistically in a randomized complete block design by the SAS (6.12) program. All experiments were conducted during the years 2003 – 2007 at the National Corn and Sorghum Research Center, Thailand.

RESULTS AND DISCUSSION

Bagging to control pollination and crossing of many planned crosses is a laborious process. Therefore, restricted time and a shortage of skilled labour resulted in missing certain crosses especially the full sib crosses of which only one male and one female were available for crossing. As a result, two TCL and five RSL were missing and therefore only 15 SFL, 15 MSL, 13 TCL and 10 RSL were available for further testing. The range of seed yield of 10 to 15 composite sibbed lines as specified for each method was; SFL, 681 – 1732; TCL, 581 – 1668; MSL, 637 – 2206; and RSL, 1150 – 2262 kg/ha, with the mean of each group being 1218, 1218, 1412 and 1587 kg/ha, respectively. Moreover, the RSL not only gave the highest mean yield, but also gave a higher minimum and maximum yield limit compared to the respective lines from other methods. Obviously, RSL and MSL are more effective

Table 1 Seed yield of top 10 super sweet corn (*sh2*) inbreds from the total of 53 lines as compared with the check, Agsh2 318, National Corn and Sorghum Research Center (October, 2007).

Encoded[1/] name	Line number [2/]	Seed yield (kg/ha)	Days to flowering (50%) Tasselling	Days to flowering (50%) Silking	Plant height (cm)	Ear height (cm)
KRSIR 9	RSL 9	2,263 a	55 b-f	56 a-d	140	59 b-g
KRSIM 5	MSL 5	2,206 ab	54 c-h	55 a-d	165	76 a-c
KRSIM 12	MSL 12	1,956 a-c	55 b-f	56 a-d	149	62 b-g
KRSIM 13	MSL 13	1,825 a-d	54 d-h	55 b-d	139	60 b-g
KRSIR 1	RSL 1	1,794 a-e	53 e-h	55 b-d	154	64 b-g
KRSIM10	MSL 10	1,769 a-e	53 e-h	55 a-d	171	47 g-f
KRSIS 14	SFL 14	1,738 a-g	55 c-h	57 a-d	144	66 b-g
KRSIR 6	RSL 6	1,731 a-g	53 f-h	56 cd	143	63 b-g
KRSIR 2	RSL 2	1,706 a-h	54 d-h	55 a-d	160	80 ab
KRSIM 1	MSL 1	1,706 a-h	55 c-g	57 a-c	136	53 c-g
Agsh2 318		1,350 c-n	54 d-h	54 cd	142	61 b-g
Mean		1,344	54.74	56.12	143	61.63
%C.V.		27.61	2.23	2.61	17.15	19.15

[1/] Coded name of inbreds.
[2/]SFL = selfing within family line.
MSL = mass sibbing within line.
RSL = recurrent sibbed line.
TCL = topcross within line.(none was selected)

methods compared to SFL and TCL methods for improving the seed yield of inbreds. The results distinctively show in Table 1 where the top 10 lines were from five MSL, four RSL, one SFL and none from TCL. Although seed yield of the top 10 lines ranged from 1,706 – 2,263 kg/ha., they was no statistical significance. Therefore, it was logical to assume that MSL and RSL were equally effective in improving the seed yield of composite lines. The only single high seed yield line from SFL should be derived from a line at the high end of the segregates in the continuous selfing processes. In addition, a confined selection for other desirable traits resulted in low phenotypic variation for all other aspects of the top 10 lines. Nonetheless, RSL lines showed the highest uniformity in general appearance. This might have been due to the crossing method of RSL which lead to a lower genetic variation and a higher level of gene equilibrium than that of MSL. Although SFL and TCL had lower genetic variation than the lines from the other two methods, they were more sensitive to the surrounding environment due to low seedling vigor. This result supported the finding that the MSL had lower phenotypic variation than the lines derived from continuous selfing (Kinman, 1952).

It is generally accepted that the yield of an individual inbred has no correlation with the yield of the corresponding hybrid or alternatively the correlation is too low and thus the inbred yield is not a good criterion for the prediction of its combining ability (Lamkey and Hallauer, 1986). However, in sweet corn, the quality of the final product is the most important factor to be considered whereas yield is a trait that has to be taken into account. In this study, high-yield plants were visually selected simultaneously with quality traits in the process of line selection. However, selection was emphasized on the quality of the testcrosses and the top 10 testcrosses are presented in Table 2. Three of each were from SFL, MSL, RSL and only one was from TCL. Obviously, the TCL method not only gave lower yield inbreds, but also gave inferior hybrids in the testcross. This might be due to a higher genetic drift during the selection process of TCL over the other three methods. In TCL, genetic drift leaned towards the single male parent, whereas SFL, MSL and RSL were derived from a composite–sibbed line of three female and three male parents and thus the genetic balance of each original line was conserved in advanced lines. Therefore, the combining ability of the original line was less affected by selection (Kinman,1952). Although the yield of SFL *per se* was low, it could be increased by switching to MSL or RSL in any generation. For example in the case of the tester, the composite–sibbed 309 which was selected by SFL for 10 generations resulted in a weakening of the line and was very difficult to maintain. When the line was switched to RSL, both the yield and seedling vigor were significantly restored (unpublish data).

Although the yields of green ear, husked ear and usable ear of testcrosses from SFL, MSL and RSL were not significantly different, the testcrosses of MSL and RSL tended to have a higher fresh-ear yield than that from SFL and TCL (Table 2). The results also showed that the composite–sibbed line derived from either the one (MSL) or three (RSL) original lines was equally effective in hybrid combinations. Moreover, the yield of parent lines did not reflect on the yield of the corresponding hybrids. Therefore, direct testing for hybrid combinations of the selected lines is necessary. In sweet corn, most quality traits are controlled by recessive genes of which act additively (Tracy, 2001) and thus a good balance between the yield and quality of parent lines is very important, especially where a single cross is the priority of the breeding program. However, the high seed yield lines, MSL 1 and RSL 4 not only gave high, fresh-ear, yield hybrids but also had fresh ears of exceptional quality. The results reflected the possibility of using a composite–line method for improving the yield and quality of parent lines in sweet corn, which could be transmitted to the corresponding hybrids.

Table 2 Seed yield of female parents and the characteristic parameters of 10 selected testcrosses, giving selection priority to the quality traits of testcrosses. All experiments were conducted at the National Corn and Sorghum Research Center, Thailand (October, 2007).

Crosses	Female's seed yield (kg/ha)	Fresh yield (kg/ha)			Husked/ Green (%)	Recovery (%)	Tipfill (cm)	Cob width depth (cm)	Kernel rows (cm)	Kernel traits (no)	Quality[1/]
		Green ear	Husked ear	Usable ear							
SFL 5/C 309	1,472 b – k	9,560 a – i	7,179 a – g	6,878 a – g	75	47	18	4.26	0.86	14	exceptional
SFL 12/C 309	1,572 a – h	11,778 a – b	8,314 a	7,918 a – d	71	46	19	3.90	0.79	14	good
SFL 15/C 309	1,251 c – n	12,148 a	8,425 a	8,391 a	70	42	20	4.27	0.86	14	good
MSL 1/C 309	1,703 a – h	11,879 a – b	8,857 a	8,169 a – b	75	41	20	4.19	0.76	14	exceptional
MSL 11/C 309	670 m – o	11,243 a – e	8, 555 a	7,796 a – d	76	41	17	4.09	1.19	12	exceptional
MSL 15/C 309	1,422 c – m	11,448 a – b	8,741 a	8,375 a	74	38	17	4.37	0.86	14	exceptional
TCL 12/C 309	1,250 c – n	11,634 a – c	8,067 a – c	7,609 a – d	69	44	19	4.13	0.84	14	good
RSL 3/ C 309	1,268 c – n	11,738 a – b	8,693 a	8,343 a – b	74	44	18	4.16	0.82	14	good
RSL 4/C 309	1,672 a – h	11,953 a – b	8,864 a	8,584 a	74	43	19	4.35	0.90	14	exceptional
RSL 7/C 309	1,330 c – n	11,890 a – b	8,242 a	7,648 a – d	70	40	18	4.25	0.82	14	good
Hybrix 3	-	11,038 a – e	7,688 a – d	6,774 a – g	70	41	17	4.81	0.94	18	good
Insee 2	-	10,528 a – g	6,661 a – i	6,386 a – h	63	39	17	4.24	0.89	14	good
CV (%)	27	19	18	20	11	12	4	13	23	5	

[1/] Quality traits included ear appearance, sweetness, pericarp tenderness, and flavor.

CONCLUSION

Composite sibbing is an effective method for improving the seed yield of an inbred line, especially where inbreeding depression is high. Selective mass-sibbing and recurrent-sibbing methods were equally effective, but they were superior over selfed bulk and topcross line methods. Seed yield of the parent line did not imply the superiority of the corresponding hybrid and thus testing for the combining ability of the final selected line for specific combination was necessary. However, it seemed that MSL and RSL could restore seedling vigor as well as maintain the combining ability of the original selfed line as indicated by the superior yields and the high quality hybrids from these two methods. The results reflected the possibility of using a composite-sibbing method to improve the yield and quality of the parent line of sweet corn which could be transmitted to the corresponding hybrid.

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