Improving Alfalfa Yield Using Unimproved Germplasm

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Introduction

Most germplasm used in alfalfa cultivars in the north central region of the United States is purple flowered and referred to as sativa. Yellow-flowered (falcata) alfalfa is an unadapted germplasm that has made few contributions to the current cultivars. However, our previous research has shown that sativa-falcata crosses (SFC) produce greater yield than sativa-sativa crosses (SSC). This indicates that falcata has favorable genes for yield and that the use of falcata may help improve yield in new cultivars.

Falcata germplasm can be used to improve yield in two ways. The first method is to cross elite sativa and unimproved falcata populations first, and then to conduct recurrent selection in the hybrid population to develop a cultivar. The second method is to conduct recurrent selection in unimproved falcata populations first, and then cross elite sativa and improved falcata populations to produce population hybrid cultivars.

Advanced generations beyond the F1 hybrids typically show yield declines. However, because sativa and falcata are actually different subspecies that express differences in morphology, growth habit, and so forth, the later generations of SFC may "break down" and show greater yield reductions than observed for SSC due to the distant genetic backgrounds of the subspecies. If this is possible, then the first method would not be a good choice to improve yield.

The aim of this study was to test whether advanced generations of F1 SFC hybrids show greater yield reductions than F1 SSC hybrids.

Materials and Methods

We produced three generations of plants. The F1 hybrids were produced by crossing individual plants of sativa and falcata or sativa and sativa. The F2 generation was formed by intercrossing the F1 hybrids from one paired cross; the S1 generation was formed by self-fertilizing F1 individuals. The F1, F2, and S1 generations for 4 SFC and 4 SSC were planted with three replications in August, 2003, at two locations (Ames and Nashua, IA). Each entry was planted in one-row plots, 3 m long and seeded at a rate of 75 seeds/plot. Plots were spaced 60 cm apart. Harvests for biomass were taken four times at both locations in 2004 and 2005. The yearly dry biomass of each plot (YB) was the sum of the whole plot dry biomass of the four harvests each year. Stands were scored during the first week after each harvest, and the mean stand score for each plot (MS) was the average of the stand score of the four harvests each year. The yearly dry biomass per plot (total yield) was calculated by dividing YB by MS to eliminate yield differences due to the stand.

F2 or S1 depression was measured as the deviation of F2 or S1 from the F1 hybrid total yield. Furthermore, the mean depression for each cross type (SSC and SFC) was calculated, and the significance levels were evaluated using an LSD.

Results and Discussion

In all cases, the F1 yielded more than either the F2 or S1 generations, as expected. However, the yield decline in SFC was greater than that of SSC in both locations in 2005 (Table 1). This result indicates that the later generations of SFC probably "break down" more severely than expected. Therefore, recurrent selection in SFC hybrids and their later generations is not a good choice for improving yield, and hybrid crosses (method 2) is probably a better way to use this unadapted falcata germplasm in a breeding program.

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Table 1. The difference in biomass yield between F1 hybrids and their advanced F2 or S1 generations in two cross types (sativa × sativa crosses [SSC] and sativa × falcata crosses [SFC]) grown at two locations over two years.

		2004		2005	
Location	Group	F2-F1	S1-F1	F2-F1	S1-F1
			g/plot		
Ames	SSC	-220 a	-422 a	-234 b	-1138 a
	SFC	-281 a	-572 a	-678 a	-1132 a
Nashua	SSC	-102 a	-206 a	-212 b	-686 b
	SFC	-122 a	-248 a	-568 a	-984 a

Mean values with different letters within a column are significantly different at P=0.05.