SILPHIUM PERFOLIATUM: A NORTH AMERICAN PRAIRIE PLANT WITH POTENTIAL AS A FORAGE CROP

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ABSTRACT
Cup-plant (*Silphium perfoliatum L.*) is a perennial member of the *Asteraceae* family, native to mesic sites of the North American prairie. Two experiments were conducted to gain knowledge of the performance of cup-plant grown in monoculture as a managed, harvested crop. In the first experiment, three cup-plant ecotypes grown near East Troy, WI and harvested twice per season for 3 years yielded from 9 to 11 Mg ha^{-1} each season. Mean neutral detergent fiber concentration was 385 g kg^{-1}, acid detergent fiber 290 g kg^{-1}, and crude protein 175 g kg^{-1} at late bud. The second experiment was an evaluation of performance of 28 ecotypes at three locations in Wisconsin. The mean performance was similar to the first experiment, however there was substantial variation for yield, forage quality, and pest resistance among the lines evaluated. We conclude that cup-plant has potential as a forage crop in temperate regions of the world, and that some ecotypes exhibit superior performance.

KEYWORDS
Cup-plant, Silphium, alternative forage.

INTRODUCTION
Livestock industries in regions of the world with frigid winters depend on conserved forage as a source of feed for both milk and meat production during winter. In the northcentral USA, alfalfa hay and silage and maize silage have proven to be the most productive and dependable sources of high quality conserved forage. The hazards of depending on only a few plant species for the critical winter feed supply were brought to the forefront recently. Extensive winter-kill affected nearly 40% of the alfalfa hectarage in three of the last eight years in the northcentral USA. Widespread flooding in two of the last four years delayed or prohibited planting or destroyed maize already sown. Clearly, identification of crops to fill ecological niches prone to winter-kill of perennials, or spring flooding would reduce risk faced by the livestock industry.

Cup-plant (*Silphium perfoliatum* L.) is a tall-growing member of the *Asteraceae* family indigenous to mesic regions of the original North American prairie (Gleason and Cronquist, 1963). It is still commonly found in remnants of native vegetation in the northcentral USA, and has been intentionally or unintentionally introduced to other areas (Wax, 1981). Cup-plant evolved in and thrives in the very conditions that have caused the recent failures in alfalfa and maize forage production. It is known to be consumed by livestock on rangeland or from fence rows, however the potential of cup-plant as a forage crop has not been systematically evaluated. Therefore, the goal of this research was to determine the yield, forage quality, and persistence of cup-plant grown under managed conditions and to determine if there is genetic variability for performance as a forage crop.

MATERIALS AND METHODS
Experiment 1. Three cup-plant ecotypes from Illinois, Minnesota, and Russia (original USA source of the latter is unknown) were established in single 10-m rows in a muck soil near East Troy, WI in spring 1989. Rows were spaced 1 m apart and plant spacing within rows was also 1 m. Plots were arranged in a randomized complete block design with 3 replications. Harvests were made two times per season (mid-July and mid-October) in 1990, 1991, and 1992. Fresh weight was measured in a 3-m length of each plot, and a subsample was removed for dry matter and nutritive value (neutral detergent fiber, acid detergent fiber, and crude protein) determination.

Experiment 2. Twenty eight cup-plant ecotypes collected primarily from Wisconsin, but also including those used in experiment 1, were established in rows spaced 0.75 m apart in Arlington, Lancaster, and Marshfield, WI in summer 1992. Plant spacing within the 6-m rows was also 0.75 m. Plots were arranged in a randomized complete block design with three replicates at each location. Forage was harvested a single time in mid-July in 1993, 1994, and 1995 and yield and nutritive values determined.

RESULTS AND DISCUSSION
Cup-plant seedlings developed slowly in both experiments and mechanical weed control was required during establishment. By mid-summer, the seedlings were large enough to compete with weeds. Because biomass accumulation was low during the establishment year, no harvests were taken during that season in either experiment and it seems that establishment year harvests will not be practical.

In experiment 1, dry matter yields averaged across 3 years were lower for the Russian line than for either the Minnesota or Illinois lines (Table 1). Total seasonal yields for the two highest yielding lines averaged 11 Mg ha^{-1}. This was equivalent to yield of alfalfa harvested from adjacent fields. About 80% of the yield was obtained in the July harvest when plants were approximately 2.2 m tall. Regrowth after defoliation was primarily from short rhizomes, however some axillary buds on the remaining stubble were also active. Regrowth harvested in October was vegetative and ranged from 0.5 to 1 meter tall.

When cup-plant was in the bud stage, crude protein, neutral detergent fiber, and acid detergent fiber concentrations were similar among the three lines ($p < 0.05$)(Table 1) and fiber values approximated those of alfalfa in the late bud stage. Freshly harvested cup-plant ranged from 85 to 88% moisture, so wilting will be essential before the crop can be ensiled.

In experiment 2, the range among lines for dry matter yield of cup-plant cut once each season was greater than observed in experiment 1. The three lines evaluated in experiment 1 ranked in the top half for yield in experiment 2, but there were other lines that yielded up to 20% more than the Minnesota or Illinois lines. There was also significant genetic variability for fiber and crude protein concentrations. The rankings of lines for yield and nutritive value were similar across the three locations and 3 years, allowing identification of superior lines for Wisconsin conditions.

These results demonstrate that accessions of cup-plant collected from natural stands can be managed to produce forage of similar yield and quality as alfalfa in the northcentral USA. Furthermore, cup-plant was remarkably persistent through severe winters and wet

springs that resulted in extensive winter-kill of alfalfa. There is a role for cup-plant as a forage crop in areas not suited to alfalfa or maize production because of imperfectly drained soils.

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Table 1
Yield and quality of three cup-plant accessions grown on a muck soil in southern Wisconsin[z].

Harvest/ Accession	DM Yield	DM	Crude Protein	NDF	ADF
	kg ha^{-1}	g kg^{-1}	------- g kg^{-1} DM ----------		
Harvest 1[y]					
Russia	8180a[x]	156	158	380	284
Illinois	8510b	144	176	388	294
Minnesota	8610b	144	182	387	291
Harvest 2[y]					
Russia	1390a	128	230	303	210
Illinois	2570b	126	233	266	187
Minnesota	2220b	125	233	271	178

[z] Values reported are means over three seasons.

[y] Harvest 1 was taken in mid-July and harvest 2 was taken in mid-October each year.

[x] Values in the same column within a harvest schedule with different letters are significantly different, $P<0.05$.