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A. Boe

R. Bortnem

K. F. Higgins

A. D. Kruse

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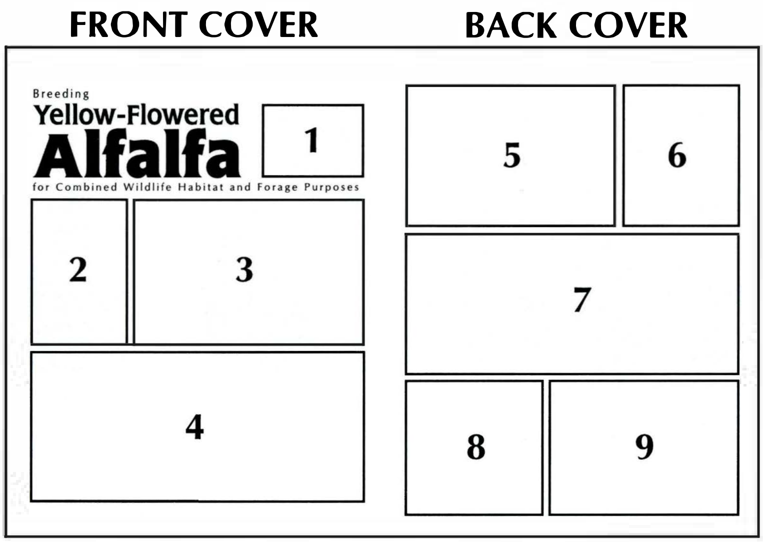
South Dakota State University • College of Agriculture & Biological Sciences • Agricultural Experiment Station • Cooperative Fish & Wildlife Research Unit



Photos collected during the project are:

1. A yellow-flowered plant that is highly resistant to potato leafhopper yellowing.
2. Seedlings ready for transplanting to field nurseries.
3. Spaced plants in September 1992, 4 months after transplanting at Highmore, showing variability of different germplasm sources.
4. Stockpiled (allowed to grow, even past optimum cutting time) forage of yellow-flowered and conventional (purple-flowered) alfalfas during July at Highmore.
5. Wildlife biologists, agronomists, and botanists cooperatively selecting yellow-flowered alfalfas for forage and nesting cover purposes. L to r, they are Kent Luttschwager, Arnold Kruse, Zeno Wicks III, Arvid Boe, Kurt Jenkins, Kevin Kephart, Spencer Vaa, and Daniel Hubbard.
6. Tubes that contain ground alfalfa and rumen fluid used in determining in vitro digestible dry matter.
7. Yellow-flowered alfalfa plants showing extensive variability for growth habit and flower production.
8. Synthetic cultivar selected for vigor, prolonged flowering, and resistance to potato heafhopper yellowing.
9. Kent Luttschwager with a visual obstruction pole evaulating spaced plants for the good height and robustness desirable for alfalfa intended for nesting habitat.

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Brookings SD 57007-1696

Breeding Yellow-Flowered Alfalfa for Combined Wildlife Habitat and Forage Purposes

A. Boe[1], R. Bortnem[1], K. F. Higgins[2], A. D. Kruse[3], K.D. Kephart[1], and S. Selman[1]

Reduced-cut forage systems (one or two cuts per growing season) are common in semiarid regions of the Great Plains and Prairie Provinces, with the first cut some time from the end of June to early August. At some locations this first cut has a deleterious effect on nesting birds.

Pheasants and ducks often use alfalfa fields for nesting sites in spring and early summer. Mowing for hay destroys a large number of nesting ringnecked pheasants (*Phasianus colchicus*) annually in midwestern states (Errington and Hamerstrom 1937, Leopold *et al.* 1943, Leedy and Hicks 1945, Baskett 1947, Stokes 1954, Allen 1956, Kimball *et al.* 1956, McCabe *et al.* 1956, Wagner *et al.* 1965, Warner 1981, Trautman 1982, Snyder 1984).

Alfalfa mowing is most destructive to nesting birds during May, June, and early July. On non-irrigated alfalfa fields, mowing typically begins around mid-June, coinciding with the typical peak of pheasant nesting.

Trautman (1982) found that in South Dakota, unless rainy weather delays alfalfa harvesting, the normal first cutting of alfalfa destroys from 32 to 39% of incubating pheasant hens and from 86 to 91% of nests. Faster-moving, higher-powered tractors, mowers, and swathers only add to the problem (Galbreath 1973).

Upland nesting waterfowl, whose nesting habits and nesting chronology are very similar to pheasants, follow the same pattern (Kirsch *et al.* 1978). In a 17-year nesting study, Higgins *et al.* (1992) found that if the negative effects from land use treatments could be ameliorated, an estimated 57% of duck nests would hatch before July 10, 78% before July 20, and 85% by July 25.

Consequently, an alfalfa type that would attain tall growth and robust vegetative development early in the nesting season but not reach maturity for harvest (first flowering) until after July 1 or later (late maturing) would be welcomed by wildlife managers seeking to improve upland nesting by ducks and pheasants.

Other birds would also benefit. A recent Saskatchewan study indicated that delaying mowing of cultivated hay until July 15 or later maintains habitat attractiveness for several species of grassland songbirds and allows many of them to fledge at least one brood in years of typical weather and normal breeding phenology (Dale *et al.* 1997).

Equally important is that late-maturing alfalfa types would also enable farmers and ranchers to stagger or prolong alfalfa haying or grazing if they planted a combination of early and late maturing alfalfa varieties.

However, stockpiling alfalfa until mid-July may encourage potato leafhopper yellowing and leaf loss. Ultimately, the alfalfa declines in yield and quality.

Yellow-flowered alfalfa (*Medicago sativa* ssp. *falcata*) has several traits that show promise in reduced-cut systems. It has high levels of winterhardiness and drought tolerance (Sinskaya 1950),

[1]Plant Science Department, and [2]US Geological Survey/Biological Resources Division, S.D. Coop Fish and Wildlife Research Unit; South Dakota State University. [3]US Fish & Wildlife Service Region 6, Refuges and Wildlife Division, Jamestown, N.D. (retired).

prolonged flowering, and more tolerance than common hay and pasture types to potato leafhopper yellowing (Bortnem *et al.* 1993, 1994, Boe *et al.* 1994).

A recent grazing study in the Aspen Parkland region of Saskatchewan demonstrated that yellow-flowered alfalfa was more persistent than the best conventional pasture-type cultivars (Bittman and McCartney 1994). These researchers suggested that yellow-flowered cultivars should be included in seed mixes for long-term pastures.

Cultivars with high levels of yellow-flowered germplasm in their parentage appear well suited for one- or two-cut systems that will provide nesting habitat for gamebirds in the spring and abundant livestock forage after young gamebirds have fledged.

The objectives of our research were to:

- evaluate a wide array of alfalfa germplasm containing varied levels of *M. sativa* ssp. *falcata* for traits related to suitability for stockpiling and nesting cover for gamebirds,
- compare yellow-flowered cultivars and germplasms to conventional hay- and pasture-type cultivars for forage yield and quality in a delayed single-harvest production system, and
- develop, by phenotypic selection, one or more synthetic cultivars of yellow-flowered alfalfa that would have high forage yield, tolerance to potato leafhopper yellowing, prolonged flowering, and good leaf retention under a stockpiling management system until mid-July.

Materials and Methods

Germplasm Sources

The germplasm we evaluated was comprised of:

- old cultivars that had *M. sativa* ssp. *falcata* as a significant component of their parentage,
- *M. sativa* ssp. *falcata* PIs obtained from the USDA Plant Introduction Station at Pullman, Wash.,
- *M. sativa* ssp. *falcata* germplasm developed by the University of Wisconsin and Colorado State University (CSU)/USDA-ARS at Ft. Collins, Colo.,
- *M. sativa* ssp. *falcata* germplasm we collected from rangeland in central South Dakota, and
- conventional hay- and pasture-type cultivars (*M. sativa* ssp. *varia* and *M. sativa* ssp. *sativa*).

The material from central South Dakota likely traces back to introductions made by N.E. Hansen in the early 1900s.

The germplasm sources that contributed to a new synthetic cultivar that is presently being evaluated in Canada for seed and forage production were:

- 29 genotypes from PIs,
- 6 genotypes from South Dakota rangelands,
- 1 genotype from 'Anik', and
- 5 genotypes from 'Kuban'.

Spaced-Plant Evaluations

In early May 1992, spaced-plant nurseries were established at Brookings [Svea (fine-loamy, mixed, Pachic Udic Haploborolls)] and Highmore [Java (fine-loamy, mixed, Mesic, Entic Haplustolls)]. The Brookings nursery contained 25 cultivars, 2 germplasms, 8 PIs, and 6 experimental populations from our breeding program (SDSU). The Highmore nursery contained 21 cultivars, 1 germplasm, 2 PIs, and 2 SDSU experimental populations. Experimental design was a randomized complete block with four replications of five-plant plots. Interplant spacing was 1 m.

The following data were obtained for individual plants from the Brookings nursery:

- potato leafhopper (*Empoasca fabae*) yellowing rating (PLYR) (Elden 1995) on July 17, 1992,
- plant height on July 19, 1993,
- dry matter yield on July 19, 1993,
- crude protein (CP) and in vitro digestible dry matter (IVDDM) concentrations for 1 plant cultivar^{-1} replication^{-1} on July 19, 1993, and
- plant shape rating (1= prostrate to 4 = upright) on Sept 24, 1993.

Data obtained from the Highmore nursery were:

- plant height on Aug 2, 1993,
- dry matter yield on Aug 2, 1993,
- CP and IVDDM concentrations for 1 plant cultivar^{-1} replication^{-1} on Aug 2, 1993, and
- plant shape rating on Oct 4, 1993.

Single-Row Seeded Evaluations

1992 Plantings. Brookings trials were planted on May 13, 1992, and Watertown trials [Brookings (fine-silty, mixed, Mesic, Entic Haploborolls)] on June 5, 1992. Entries were 8 cultivars (Kuban, Norseman, Travois, Ladak 65, Teton, Cimarron, Alfagraze, and Vernal), 2 germplasms (Wisfal and C-CSU/USDA), and 4 SDSU experimental populations. Seeding rate was 13.4 kg pure live seed (PLS) ha^{-1} in 3-m long rows spaced 1 m apart.

PLYR data were collected at Brookings on Aug 3, 1992; dry matter yield and CP and IVDDM concentrations on Aug 3, 1992, and July 19 and Sept 29, 1993. At Watertown, PLYR data were collected on Aug 19, 1992, and dry matter yield and quality on Aug 19, 1992, and July 29 and Sept 28, 1993.

1993 Plantings. Trials were planted at Brookings and Watertown on Aug 9 and May 13, 1993, respectively. Entries were 2 *M. sativa* ssp. *falcata* cultivars (Anik and Kuban), 6 *M. sativa* ssp. *varia* cultivars (Cimarron, WL 322 HQ, Travois, Vernal, Ladak 65, and Teton), 7 SDSU experimentals, and 2 germplasms (Wisfal and C-CSU/USDA). Experimental design, plot dimensions, and soil types were as described for the 1992 plantings.

PLYR data were collected at Watertown on Oct 5, 1993. Forage yield was determined on July 15, 1994, at Brookings and on July 26, 1994, at Watertown. IVDDM was determined for Brookings only. The Brookings trial was harvested for forage yield on Aug 3, 1995.

Conventional Yield Trials

Three SDSU synthetics (SD 22, SD 33, and SD 44), 5 cultivars (Vernal, Spredor 3, Travois, WL 322HQ, and Alfagraze), and 1 germplasm (Wisfal) were planted at Brookings [Lismore silty-clay loam (fine-loamy, mixed, Pachic Udic Haploboroll)] and Highmore (soil described above) during August 1994.

The synthetic cultivars were developed by phenotypic selection for plant shape, prolonged flowering, forage yield, and tolerance to potato leafhopper yellowing and were from Kuban, Anik, PIs, and rangeland ecotypes.

Planting rate was 13.4 kg PLS ha^{-1}. Experimental design was a randomized complete block with four replications. Plots were 6.1 m long and consisted of 5 rows with 15-cm spacing.

The two trials were harvested twice (mid-July and late September 1995 and once in 1996 in mid-July). The Highmore trial was also harvested during mid-July 1997.

Dry matter forage yield data were collected for all harvests. Crude protein and IVDDM were determined for 1995 harvests.

Harvest Methods, Laboratory Analyses, Statistical Analyses

The spaced-plant and single-row evaluations were harvested with hand-operated tools. Conventional trials were harvested with a sickle-bar mower.

Individual plants from spaced-plant nurseries were dried at 37 C to constant weight to determine dry matter yield. Fresh forage from single-row and solid-seeded plots was weighed in the field. Forage subsamples from each plot were dried at 37 C to determine dry matter yields.

Samples for quality analyses were ground to pass through a 1-mm screen and then scanned with a scanning monochromotor near infrared reflectance spectrometer (NIRS Systems, model 5000). Calibration equations were computed for concentrations of CP and IVDDM. References for CP were mass spectrometry for total N concentration (ANCA-NT/20 20 Isotope Ratio Mass Spectrometer, Europa Scientific). IVDDM was determined after Marten and Barnes (1980).

Data were subjected to analyses of variance. Entries (cultivars, PIs, germplasms, experimentals) and locations were considered to be random. Differences among entry means were tested by Fisher's protected least significant difference at P = 0.05.

Results

Spaced Plantings and Single-Row Evaluation

1992 Results from 1992 Plantings. Highly significant differences were found among entries for CP of stockpiled seeding-year forage at Brookings.

Kuban, a yellow-flowered cultivar from the former USSR, had 2 to 3% higher protein (158 g kg^{-1}) than other entries (Table 1).

Cultivars with high levels of yellow-flowered germplasm in their pedigrees (Travois, Teton, Kuban) had high IVDDM at Brookings and Watertown. For example, mean IVDDM across locations was 687 g kg^{-1} for Travois compared to 623 g kg^{-1} for Cimarron, which has no yellow-flowered germplasm in its pedigree (Table 2).

Potato leafhopper populations were heavy during the growing season, and the conventional cultivars were noticeably stunted

• Table 1. Crude protein concentration of stockpiled seeding-year forage of 14 entries, August 1992, Brookings, S.D.

Entry	*Protein* *g kg^{-1}*
Kuban[4]	158
D_2[3]	140
Teton	138
Alfagraze	138
Travois	137
C-CSU/USDA-ARS[1]	135
Cimarron	134
Vernal	133
T_2-5[3]	133
Norseman	131
AFYF[3]	129
Wisfal[2]	127
SDHL[3]	127
Ladak 65	127
LSD (0.01)	12

[1] Large-seeded yellow-flowered germplasm obtained from C.E. Townsend, USDA-ARS, Ft. Collins, Colo.
[2] Tetraploid yellow-flowered germplasm obtained from E.T. Bingham, Univ of Wisconsin-Madison.
[3] Experimental populations from SDSU.
[4] Yellow-flowered cultivar from the former Soviet Union.

and discolored by their feeding. Yellow-flowered materials were much more tolerant of potato leafhopper yellowing than the other entries in a spaced-plant nursery (Table 3).

1993 Results from 1992 Plantings. Highly significant differences were found among entries for yield of forage stockpiled until late July in eastern South Dakota.

Highest-yielding entries were yellow-flowered types. Kuban produced over 40% more forage than Alfagraze and Vernal under this 1-cut delayed harvest system (Table 4).

Highly significant differences were found among entries for CP and IVDDM of forage stockpiled

• Table 2. In vitro digestible dry matter of stockpiled seeding-year forage,14 entries, August 1992, two locations in eastern South Dakota.

Entry	*Brookings*	*Watertown*
	— *g kg^{-1}*	—
Travois	654	720
Teton	653	707
Kuban	651	685
Wisfal	646	706
D_2	635	717
C-CSU/USDA-ARS	633	710
Norseman	626	695
T_2-5	603	686
Vernal	602	699
SDHL	597	688
Ladak 65	587	677
Alfagraze	562	708
Cimarron	555	692
AFYF	557	689
LSD (0.01)	40	

until late July. The CP of Kuban (115 g kg^{-1}) was significantly lower than that of all other entries. Grand means were 138 g kg^{-1} for CP and 528 g kg^{-1} for IVDDM (Table 4).

In spaced-plant nurseries, yellow-flowered PIs, cultivars, and experimentals were the highest yielders, while conventional cultivars (Cimarron, Alfagraze) were the lowest (Tables 5 and 6).

Significant differences were found among entries in spaced-plant nurseries at Brookings and Highmore for CP and at Brookings for IVDDM. Kuban (90 g kg^{-1}) and PI 315476 (102 g kg^{-1}) had the lowest CP concentrations at Highmore, while 'Narragansett' and 'Beaver' had the highest (126 g kg^{-1}) (Table 6). CP concentrations for Kuban and PI 315476 were 108 and 106 g kg^{-1} at Brookings compared to the grand mean of 129 g kg^{-1} and a high of 151 g kg^{-1} for Cimmaron. Five out of the 8 yellow-flowered PIs evaluated at Brookings ranked in the lower 25%

• Table 3. Means and standard deviations for leafhopper yellowing* evaluated in July 1992 in a spaced-plant nursery at Brookings, S.D.

Entry	*n*	*Leafhopper yellowing**
SDMF-1[2]	18	1.3 + 0.6
Kuban	38	1.5 + 0.7
Anik	20	1.6 + 0.5
KSE[2]	18	1.6 + 0.5
Kane	18	1.9 + 0.7
Wisfal	19	2.1 + 0.7
Travois	18	2.4 + 0.8
Cimarron	30	2.5 + 0.6
Alfagraze	20	2.5 + 0.9
Heinrichs	29	3.0 + 0.8
Vernal	70	3.3 + 0.7
Drylander	30	3.2 + 0.6
Beaver	20	3.3 + 0.7
PI 251689[1]	30	1.0 + 0.2
PI 325406[1]	38	1.0 + 0.2
PI 231731[1]	40	1.1 + 0.3
PI 315476[1]	20	1.2 + 0.5
PI 325408[1]	19	1.3 + 0.4
PI 325383[1]	39	1.3 + 0.6
PI 384507[1]	40	1.4 + 0.7
PI 346921[1]	39	2.5 + 1.0

* Scale was from 1 = 0 - 20% foliar discoloration to 5 = all leaves yellow and stem wilted.
[1] *Medicago sativa* ssp. *falcata* accessions obtained from Plant Germplasm Introduction and Testing, USDA-ARS-NWA, Washington State Univ., Pullman, Washington
[2] Experimental *Medicago sativa* ssp. *falcata* population from SDSU.

• Table 4. Mean dry matter forage yield, crude protein, and IVDDM of alfalfa stockpiled until late July in seeded trials at two locations in eastern South Dakota in 1993.

Entry	*Yield* *kg ha^{-1}*	*CP* *g kg^{-1}*	*IVDDM* *g kg^{-1}*
Kuban	8320	115	507
C-CSU/USDA -ARS	6860	136	528
AFYF[1]	6774	141	526
Norseman	6771	133	523
Wisfal	6694	133	509
Travois	6552	148	550
Ladak 65	6354	137	526
Teton	6244	140	542
Cimarron	6220	152	541
T_2-5	6129	135	523
Alfagraze	5915	140	524
Vernal	5732	138	527
SDHL	5455	145	533
D_2	4736	144	551
LSD (0.05)	993	9	24

• Table 5. Means and standard errors for dry matter yields of the 10 highest- and the 10 lowest-yielding entries in a spaced-plant nursery stockpiled until late July at Brookings, S.D., in 1993.

Entry	*Yield* *g plant^{-1}*
– High –	
SDMF-1	643 ± 87
PI 251689	639 ± 38
PI 231731	572 ± 41
Kuban	538 ± 52
PI 315476	514 ± 52
C-CSU/USDA-ARS	476 ± 66
Wisfal	460 ± 48
PI 346921	454 ± 47
PI 325383	452 ± 57
– Low –	
Alfagraze	352 ± 29
Anik	349 ± 33
Iroquois	337 ± 35
Trek	332 ± 18
Cossack	325 ± 29
D_2	312 ± 49
Mark II	290 ± 28
PI 325408	233 ± 43
Cimarron	194 ± 24

• Table 6. Means and standard errors for dry matter yields and crude protein of spaced-plants stockpiled until late July, Highmore, S.D. in 1993.

Entry	*Yield* *g plant^{-1}*	*CP* *g kg^{-1}*
PI 346921	1311 ± 152	113
Kuban	1182 ± 133	90
PI 315476	963 ± 97	102
C-CSU/USDA -ARS	889 ± 104	102
D_2	878 ± 73	109
Drylander	842 ± 107	111
Beaver	829 ± 81	126
Kane	770 ± 76	109
Rambler	761 ± 78	110
Rhizoma	761 ± 69	124
Rangelander	718 ± 52	113
Agate	690 ± 49	115
Ladak 65	690 ± 74	118
Heinrichs	652 ± 66	119
Narragansett	645 ± 100	126
Cossack	624 ± 47	116
Iroquois	586 ± 59	122
Alfagraze	558 ± 78	112
Cimarron	365 ± 29	117
LSD (0.05)		17

• Table 7. Mean CP and IVDDM concentrations of spaced plants stockpiled until late July at Brookings, S.D., in 1993. The 10 highest and 10 lowest entries for CP concentration are given.

Entry	*Protein*	*IVDDM*
	g kg^{-1}	
High Protein		
Cimarron	151	542
Valor	151	565
Mark II	143	552
Agate	142	563
Alfagraze	141	542
Anik	140	559
Teton	139	548
Drylander	139	560
Travois	138	549
Beaver	138	548
Low Protein		
Rangelander	124	529
Iroquois	124	525
PI 251689	122	525
Ladak 65	118	507
PI 325408	117	518
C-CSU/USDA -ARS	114	509
PI 231731	111	505
Kuban	108	514
PI 325383	107	512
PI 315476	106	488
LSD (0.05)	22	47

for CP (Table 7). Similar trends were observed for IVDDM of yellow-flowered alfalfa compared to standard pasture and hay types.

We feel that the higher forage quality characteristics of the yellow-flowered compared to standard types in 1992 was likely due to potato leafhopper feeding. Potato leafhopper infestations were heavy in 1992, and the yellow-flowered germplasms (e.g., Kuban) were highly tolerant. Heavy feeding on seedlings caused extensive leaf drop in the standard types, reducing the quality of their forage to a greater extent than for the yellow-flowered types which retained their leaves.

Significant differences were found among entries for height of stockpiled forage of spaced plants. Kuban was the tallest entry, while several pasture-type cultivars (Rambler, Roamer, Drylander, and Travois) were among the shortest entries (Table 8).

These results suggested that height of initial growth that was stockpiled until early August was not necessarily determined by germplasm source (Barnes *et al.* 1977). On the other hand, erectness of regrowth was strongly influenced by germplasm source.

In general, conventional cultivars (Iroquois, Cimarron, and Vernal) had more erect regrowth than entries with *M. sativa* ssp. *falcata* as their sole or primary source of parentage (Table 9). This relationship was expected, since the regrowth potential of *M. sativa* ssp. *falcata* is substantially lower than that of *M. sativa* ssp. *varia* (Sinskaya 1950).

1994 Results from 1993 Plantings. As was found in 1993 for trials seeded in 1992, the forage production of Travois, Kuban, C-CSU/USDA-ARS, and AFYF in 1994 from trials seeded in 1993 was relatively high compared to standard hay-type cultivars (Cimarron, Vernal, and WL 322 HQ) (Table 10).

Data were not collected from the Watertown trial due to stand loss caused by inundation in spring 1994.

The 1994 data support our previous findings regarding the yield advantage of cultivars with high levels of yellow-flowered germplasm in their genetic backgrounds when forage is stockpiled

• Table 8. Means and standard errors for plant heights[1] of spaced-plants on 2 August 1993 at Highmore, S.D. Only the ten tallest and ten shortest entries are given.

Entry	Height[1] cm
Tallest	
Kuban	75.4 ± 4.3
Alfagraze	72.7 ± 3.3
Cossack	72.6 ± 3.4
Beaver	71.8 ± 2.5
Narragansett	71.0 ± 3.6
PI 315476	69.8 ± 3.6
Teton	69.2 ± 3.0
Ladak 65	69.1 ± 3.4
Agate	68.3 ± 2.7
Valor	67.0 ± 2.3
Shortest	
Heinrichs	64.7 ± 2.0
Rangelander	63.2 ± 3.0
D_2	62.6 ± 2.6
Spredor II	62.5 ± 2.2
Rhizoma	61.9 ± 2.3
Drylander	60.3 ± 3.2
Rambler	59.2 ± 2.7
Roamer	58.1 ± 2.4
Travois	55.0 ± 2.7
PI 346921	50.5 ± 4.0

[1] Measured from ground level to tip of uppermost stem in canopy.

until mid-July. IVDDM of Kuban continued to be lower than for conventional cultivars (Table 10).

Conventional Plantings

1995 Results from 1994 Plantings. Highly significant (P<0.01) differences were found among cultivars for dry matter forage yield, IVDDM, and CP (Tables 11 and 12).

Location x cultivar interactions were only significant for second-harvest yields and total forage yields.

The yellow-flowered synthetics SD 22 and SD 44 produced significantly more first-harvest forage than all other entries at both locations. At Highmore, SD 44 also produced significantly more total forage yield than all entries other than SD 22 (Table 11). Total forage production at Brookings for SD 22 and SD 44 was similar to that of the conventional cultivars.

First-harvest IVDDM and CP were significantly higher for WL 322 HQ than all other entries. First-harvest IVDDMs of the three yellow-flowered synthetics were similar to those of all entries other than WL 322 HQ, but their CPs were significantly lower than those of Travois, Spredor 3, and Alfagraze. Second-harvest IVDDM and CP for the three yellow-flowered synthetics were significantly greater

• Table 9. Means and standard errors for regrowth of spaced-plants on 24 September 1993, Brookings, S.D. Plants were harvested 19 July 1993. Only the 10 most upright and the 10 most prostrate entries are given.

Entry	Growth habit[1]
Upright	
Agate	3.85 ± 0.05
Valor	3.85 ± 0.06
Cossack	3.84 ± 0.05
Iroquois	3.84 ± 0.05
Cimarron	3.83 ± 0.05
Mark II	3.83 ± 0.05
Alfagraze	3.82 ± 0.05
Vernal	3.77 ± 0.03
Trek	3.75 ± 0.05
Ladak 65	3.69 ± 0.06
Prostrate	
PI 251689	2.90 ± 0.05
PI 325383	2.72 ± 0.10
PI 315476	2.58 ± 0.20
Kuban	2.54 ± 0.16
PI 346921	2.50 ± 0.05
KSE	2.50 ± 0.17
Anik	2.46 ± 0.16
PI 325408	2.43 ± 0.30
PI 231731	2.33 ± 0.09
PI 325406	1.77 ± 0.15

[1] Scale was 1 = prostrate, 2 = semi-sprawling, 3 = bowl-shaped, 4 = upright after Sinskaya (1950).

• Table 10. Mean dry matter forage yield and IVDDM of alfalfa stockpiled until late July 1994, Brookings, S.D., from a trial seeded in August 1993.

Entry	IVDDM g kg^{-1}	Yield kg ha^{-1}
Travois	534	6496
C-CSU/USDA-ARS	548	6496
Ladak 65	479	6272
T2-5	531	6272
D2	528	6048
AFYF	562	6048
Kuban	491	6048
Teton	560	5824
Cimarron	553	5376
WL 322 HQ	558	4928
Vernal	532	4704
LSD (0.05)	34	1344

• Table 11. Mean dry matter forage yields of alfalfa in a reduced-cut system, two locations in eastern South Dakota in 1995.

Cultivar	First harvest yield, avg across locations	Total yield Brookings	Total yield Highmore
	kg ha^{-1}		
SD44	6989	7235	11558
SD22	6944	7123	11155
Travois	6160	7146	10080
Wisfal	6026	8221	10125
Spredor 3	5936	7795	9878
Vernal	5645	7302	10058
WL 322 HQ	5510	7347	9363
Alfagraze	5488	7370	9475
SD33	5443	6093	9117
LSD (0.05)	650	1142	

• Table 12. Forage quality of alfalfa averaged across two locations in eastern South Dakota in 1995.

Cultivar	IVDDM Harvest 1st	IVDDM Harvest 2nd	Crude protein Harvest 1st	Crude protein Harvest 2nd
	g kg^{-1}			
SD44	539	610	135	179
SD22	536	622	135	188
Travois	544	569	150	150
Wisfal	544	587	137	159
Spredor 3	546	547	151	141
Vernal	539	545	144	136
WL 322 HQ	559	554	160	140
Alfagraze	543	555	150	143
SD33	537	609	141	174
LSD (0.05)	11	12	5	11

than those for all other cultivars (Table 12).

Highly significant differences occurred between locations for forage yield and quality parameters. Total forage yield at Highmore was about 40% greater than at Brookings. First-harvest IVDDM and CP were significantly higher at Brookings than at Highmore, while the reverse was true for the second harvest.

1996 and 1997 Results from 1994 Plantings. In 1996 the grand mean dry matter yield was 5800 kg ha^{-1}. No significant differences were found among cultivars.

In 1997, forage yield data were only collected at Highmore due to pocket gopher damage at Brookings. There was a significant difference among cultivars, with WL 322 HQ yielding significantly less forage than all other cultivars (grand mean = 7800 kg ha^{-1}).

Development of a Synthetic Cultivar

During July 1992 the spaced-plant nurseries were evaluated for traits (general vigor, growth habit, and plant shape) that might be desirable in an alfalfa cultivar to use as nesting cover for waterfowl and pheasants. We selected and cloned 41 genotypes based on general vigor, tolerance to potato leafhopper yellowing, leaf retention, and semi-erect to erect growth habit (Table 13).

These genotypes were transplanted to four cages at Prosser, Wash., for production of Syn 1 seed. Each cage contained a different combination of 12 genotypes, but they all had several genotypes in common. We gave the four synthetic cultivars the experimental designations SD 11, SD 22, SD 33, and SD 44. They produced a total of about 1000 g of Syn 1 seed.

In 1994 we sent 200 g of Syn 1 (bulk of 50 g each of SD 11, 22, 33, and 44) back to Prosser for seed production increase on an isolation field. That field produced about 3 kg of Syn 2 seed which was designated SD 201.

In 1996, small amounts of SD 201 seed were sent to Alberta Agriculture, Food, and Rural Development, Lacombe, Alberta, Can, for forage yield evaluations and to Newfield Seeds Co. Ltd., Nipawin, Saskatchewan, Can, for seed production evaluation. A seed increase will be planted near Bismarck, N.D., during 1998 in cooperation with the Bismarck Plant Materials Center (USDA-NRCS). Seed will be available in 1999 and beyond to qualified producers for certified seed production.

Trials that included SD 201 were successfully established in 1996, and data will be collected over the next several years.

• Table 13. The sources and number of genotypes from each source that comprise the synthetic cultivar SD 201.

Accession/ Cultivar/ Experimental	*Number of genotyhpes in synthetic*
PI 231731	5
PI 251689	5
PI 315476	4
PI 325383	4
PI 325406	5
PI325408	3
PI384507	3
E 82M8S[2]	1
E 82M16S	1
E KSE	1
E SDMF-1	3
Anik	1
Kuban	5

[2] E, experimentals from SDSU.

Discussion

Forage production of alfalfa stockpiled until mid- or late July was highest for entries that had yellow-flowered alfalfa as their sole or primary source of parental genotypes.

However, our data suggest that germplasms with high levels of yellow-flowered alfalfa in their pedigrees were poorer quality than many standard hay or pasture types under a delayed first-harvest system when potato leaf-hopper infestations were not severe.

We suggest that if alfalfa is intended to be stockpiled until mid-July or later, plant tolerance to potato leafhopper yellowing is crucial. Timing and level of potato leafhopper infestations are difficult to predict, but if the insects arrive early in the growing season they can cause significant reductions in yield and quality of susceptible cultivars if the forage is stockpiled until mid-July.

Germplasms with high levels of yellow-flowered alfalfa in their parentage appear promising for one-cut systems that will provide suitable nesting habitat for gamebirds in the spring and summer and abundant livestock forage after young gamebirds have fledged.

Since forage yields of yellow-flowered germplasms generally exceed those of standard and hay- and pasture-type cultivars in a delayed-harvest system, future work should focus on selecting for improved quality in yellow-flowered alfalfa. SD 201, Kuban, and several PIs have the vegetative characteristics needed in an alfalfa cultivar intended for wildlife habitat and livestock forage. However, a major roadblock to development of a yellow-flowered cultivar for combined wildlife habitat and livestock forage purposes is poor seed production.

Results of long-term studies in Canada suggest that the advantage of yellow-flowered alfalfa over conventional hay and pasture types is expressed several years after establishment due to the yellow-flowered type's superior persistence and tolerance to biotic and abiotic stresses (Bittman *et al.* 1991, Bittman and McCartney 1994). Rodent damage prevents collection of additional data from stands established in fall 1994.

However, we plan to establish grass/alfalfa mixture plots in 1998. The treatments will include SD 201, Alfagraze, and Cimarron in mixtures with intermediate wheatgrass (*Thinopyrum intermedium*) and green needlegrass (*Stipa viridula*). We will apply the same one-cut management system on these mixtures over a 4- to 5-year period. Forage yield and quality data will provide insight into the adaptability of our new yellow-flowered synthetic cultivar compared to conventional hay and pasture types in mixtures with native and introduced cool-season grasses.

Summary and Conclusions

1. The experimental synthetic we developed and other yellow-flowered germplasms with similar morphological and phenological characteristics (e.g., Kuban) are ideally adapted to a delayed one-cut system. They possess vigorous spring growth, prolonged flowering, substantial vegetative growth and excellent leaf retention after full bloom, and a high level of resistance to yellowing and stunting caused by potato leafhoppers.

It should be pointed out that the major difference between maturity characteristics of yellow-flowered and conventional cultivars is not in the time of onset of flowering. In fact, yellow-flowered germplasm may begin blooming a few days earlier than conventional types, but they exhibit longer duration of flowering and greater amount of vegetative growth than conventional types between onset of flowering and August 1 in the northern Great Plains.

2. The yellow-flowered types have potential to produce substantially more forage than conventional cultivars when the first harvest is delayed until mid-July, but the quality of first-cut forage produced by yellow-flowered types will generally be poorer than that of conventional types unless potato leafhoppers are present.

However, resistance to yellowing and stunting caused by potato leafhopper feeding is essential for any alfalfa intended for stockpiling until mid-July or later in the northern Great Plains. Since yellow-flowered types typically out-yield conventional types in a one-cut system, the actual amount of protein produced per unit area is similar for the two types.

3. Our results and observations strongly indicate that several yellow-flowered germplasm types provide early, tall vegetative growth (physionomic characteristics) that would be attractive and suitable for upland bird nesting from early spring through early August.

These types also maintained these characteristics throughout the primary nesting period for ducks and pheasants without substantial loss of forage quality.

However, widespread use of yellow-flowered alfalfa for forage production and nesting cover is dependent upon economical seed production. To date, suitable seed production environments have not been identified and management practices for seed production have not been developed. Yellow-flowered material has inherently lower seed production potential (Sinskaya 1950) because it is highly indeterminate and its sickle-shaped pods are more likely to shatter than the coiled pods of conventional cultivars.

The most promise for improving seed production will likely come from a management practice that stimulates the plants to produce a large flush of flowers over a relatively short period of time. Such a practice would result in an abundance of flowers of similar age for pollinators and potentially a large crop of seed of uniform age and maturity.

Literature cited

Allen, D.L., ed. 1956. Pheasants in North America. Washington, DC: Wildl Manage Inst.

Barnes, D.K., E.T. Bingham, R.P. Murphy, O.J. Hunt, D.F. Beard, W·H. Skrdla, and L.R. Teuber. 1977. Alfalfa germplasm in the United States: genetic vulnerability, use, improvement, and maintenance. USDA Tech Bull 1571.

Baskett, T.S. 1947. Nesting and production of the ring-necked pheasant in north-central Iowa. Ecol Monogr 17:1-30.

Bittman, S. and D.H. McCartney. 1994. Evaluating alfalfa cultivars and germplasms for pastures using the mob-grazing technique. Can J Plant Sci 74:109-114.

Bittman, S., J. Waddington, and D.H. McCartney. 1991. Performance of alfalfa strains grown in mixture with smooth bromegrass as affected by management. Can J Plant Sci 71:1029-1037.

Boe, A., R. Bortnem, and A. Kruse. 1994. Forage yield of stockpiled yellow-flowered and hay-type alfalfas. P 132. *in* Report, 34th N Amer Alfalfa Improvement Conf.

Bortnem, R., A. Boe, and A. Kruse. 1994. Forage quality of stockpiled yellow-flowered and hay-type alfalfas. P 132 *in* Report, 34th N Amer Alfalfa Improvement Conf.

Bortnem, R., A. Boe, K. Higgins, and A. Kruse. 1993. Evaluation of alfalfa germplasms for combined wildlife habitat and forage purposes. P 29 in Proc, 23rd Central Alfalfa Improvement Conf.

Dale, B.C., D.A. Martin, and P.S. Taylor. 1997. Effects of hay management on grassland songbirds in Saskatchewan. Wildlife Soc Bull 25:616-626.

Elden, T.C. 1995. Potato leafhopper yellowing. P I-5 *in* (C.C. Fox, R. Berberet, A. F. Gray, C.R. Grau, D.L. Jesen, and M.A. Peterson, eds) Standard tests to characterize alfalfa cultivars, 3rd ed. N Amer Alfalfa Improvement Conf.

Errington, P.L. and F.N. Hamerstrom. 1937. Evaluation of nesting losses and juvenile mortality of the ring-necked pheasant. J Wildl Manage 1:3-20.

Galbreath, D.S. 1973. Pheasant population studies and pheasant nest losses form alfalfa mowing operations in the Columbia Basin of central Washington. Proc, W Assn of State Fish and Game Comm 53:326-335.

Higgins, K.F., L.M. Kirsch, A. T. Klett and H.W. Miller. 1992. Waterfowl production on the Woodworth Station in southcentral North Dakota, 1965-1981. U.S. Fish and Wildlife Service Resource Pub 180.

Kimball, J.W·, E.L. Kozicky and B.A. Nelson. 1956. Pheasants of the plains and prairie. P 204-236 *in* (D.L. Allen, ed) Pheasants in North America. Washington, DC: Wildl Manage Inst.

Kirsch, L.M., H.F. Duebbert, and A.D. Kruse. 1978. Grazing and haying effects on habitat of upland nesting birds. Trans, N Amer Wildlife and Natural Resources Conf 43:486-497.

Leedy, D.L. and L.E. Hicks. 1945. Pheasants in Ohio. P 57-130 *in* (W.L. McAtee, ed) Ring-necked pheasant and its management in North America. Washington, DC: Am Wildl Inst.

Leopold, A., T.M. Sperry, W.S. Feeney and J.A. Catenhusen. 1943. Population turnover on a Wisconsin pheasant refuge. J Wildl Manage 7:383-394.

Marten, G.C. and R. F· Barnes. 1980. Prediction of energy digestibility of forages with *in vitro* rumen fermentation and fungal enzyme systems. P 61-71 *in* Standardization of analytical methodology for feeds. Ottawa, Canada: Internatl Development Research Centre.

McCabe, R.A., R.A. MacMullan, and E.H. Dustman. 1956. Ringneck pheasants in the Great Lakes region. P 264-356 *in* (D.L. Allen, ed) Pheasants in North America. Harrisburg, PA: Stackpole Co and Washington, DC: Wildl Manage Inst.

Sinskaya, E.N. 1950. Flora of cultivated plants of the U.S.S.R. XIII Perennial leguminous plants. Part I Transl. 1961. Jerusalem: Israel Program of Scientific Translations.

Snyder, W.D. 1984. Ring-necked pheasant nesting ecology and farming on the high plains. J Wildl Manage 48:878-888.

Stokes, A.W. 1954. Population studies of the ring-necked pheasant on Pelee Island, Ontario. Toronto: Tech Bull, Wildl Ser 4, Ontario Dep Lands Forests.

Trautman, C.G. 1982. History, ecology and management of the ring-necked pheasant in South Dakota. Pierre: South Dakota Game, Fish Parks Dept.

Wagner, F.H., C.D. Besadny, and C. Kabat. 1965. Population ecology and management of Wisconsin pheasants. Madison: Wisconsin Dep Conserv Tech Bull 43.

Warner, R.E. 1981. Illinois pheasants: population, ecology, distribution, and abundance, 1900-1978. Biol Ill Nat Hist.Surv Notes 115.

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