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Preedicting Seed and Forage Yields of Alfalfa Open Pollinated Progenies

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PROJECT: NC-83 Seed Production of Breeding Lines of Insect-Pollinated Legumes

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Sponsored by the agricultural experiment stations of South Dakota, Nebraska, Indiana, Minnesota, Kansas, Iowa, and the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture under the auspices of the NC-83 Technical Committee "Seed Production of Breeding Lines of Insect Pollinated Legumes."

SUMMARY

Twenty-nine alfalfa clones from breeding programs at the Agricultural Experiment Stations of Indiana, Iowa, Kansas, Minnesota, Nebraska, and South Dakota were vegetatively propagated and replicated in space-planted nurseries established in those six North Central states and California and Idaho. Measured were 18 plant characteristics in the North Central tests and seed yields in the western states. Open pollinated seed from California and Idaho was used to sow seed yield trials in those states as well as multiple row forage yield trials in Iowa, Kansas, Nebraska, and South Dakota. Agronomic data other than yield were obtained from the progeny plantings. The experiments were to determine if associations among characters existed strongly enough to predict seed yield in the western states' commercial seed producing regions and forage yield in North Central states, using knowledge of plant morphology of clones and of progenies in the North Central seed consuming area.

No one character or group of clonal characters could be used uniformly in predictive equations. Considering predictive value and cost and difficulty of measuring, we selected five (date of initial bloom, flower color score, growth habit score, percentage of fertile, open-pollinated florets and number of coils per pod) as being best suited to indicate progeny seed yield potential in California and Idaho. Percentage of fertile, open-pollinated florets and number of coils per pod predicted seed yield better than other traits. The five variables selected proved suitable for predicting average forage yield of open-pollinated progenies in the North Central States.

Forage yield was the only North Central Region progeny trait average that correlated significantly with average seed yield in the Western states (r=.40). Highest coefficient of determination was .87, which was obtained from 19 independent clonal variables measured in Kansas and used to predict progeny seed yield in Idaho. Progeny traits did not precisely predict seed yields but the results were encouraging. Characters like forage yield, stand, rate of recovery, and fall growth habit are either routinely measured in alfalfa breeding programs or can be easily measured. Combining both clonal and progeny trait information was more valuable for predicting forage than seed yields.

We conclude that genotypes sufficiently winter hardy to maintain stand and vigor and capable of rapid recovery after cutting provide both maximum forage and maximum seed yields.

Predicting Seed and Forage Yields of Alfalfa Open-Pollinated Progenies

By
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INTRODUCTION

Breeding alfalfa *(Medicago sativa* L., *M. falcata* L., and their hybrids) in the United States is complicated because geographic centers for seed and forage production are widely separated. The domestic seed production is concentrated in western states (California, Oregon, Washington, and Idaho). More than half the country's alfalfa forage acreage is in 12 states in the North Central Region. The two areas differ climatically. Clones and cultivars well adapted to one region and purpose are not necessarily well adapted to the other region or to other purposes.

Selecting traits measured in North Central Region nurseries has contributed to agronomically superior cultivars for forage production in the region, but not all of them have the genetic capacity for high seed yield in the western states. Seeds of such cultivars have been more expensive than seed of more prolific cultivars. Simultaneous selection for increased forage and seed yields by traits that can be measured rapidly and inexpensively in North Central states is desired. That will be possible only if such traits are highly heritable and also are genetically correlated with yield attributes. For those reasons experiments were initiated in 1966 to determine: (a) whether associations between seed production potential and morphological- or physiological-plant characteristics exist, and (b) if such associations can be used to identify plants with both forage and seed production potentials.

REVIEW OF LITERATURE

In alfalfa breeding programs, germplasm normally is examined and plants or clones with superior agronomic characteristics are selected in spaced nurseries before solid-stand progeny trials are used to measure seed or forage yield. Therefore, population density's effects on plant morphology is important. Plant height, plant width, stem number, and stem length accounted for 93% of dry matter forage yield variation in noncompetitive space-planted experiments by Frakes *et al.* (2), but the relationships of crown width, stem number, and stem length to plant forage weight changed as plant spacing changed (10). Experiments in the North Central Region have shown that data from spaced plantings do not reliably indicate forage yield potential in solid seeded stands (1, 8, 10, 12, 13).

Miller *et al.* (7) reviewed several earlier reports of correlations between various forage yield components and forage yield of alfalfa in solid seedings. They were determining predictors of individual plant yield and its components in a solid seeded stand with varying distances among neighboring plants and irregular orientation of plants in field environments. Total dry matter yield of a plant and its number of stems could be predicted more reliably than could weight per stem, using five independent variables: (a) spring crown area of the plant, (b) dry weight of the previous harvest, (c) distance to nearest neighbor, (d) potential area of plant, and (e) nearest neighbor's number of stems. In their studies effects of the independent variables varied for different harvests of a variety and for different varieties. Crown area and yield of the previous harvest were the most important influences on yield. Potential area of a plant was significant on a seasonal basis but not an important predictor of individual harvest yields. Nearest neighbor's number of stems predicted plant yield and its components better than distance to the neighbor did.

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[1]Contribution from cooperative investigators of South Dakota State University, University of Nebraska, Kansas State University, Iowa State University, University of Minnesota and the Plant Science Research Division, Agricultural Research Service, U. S. Department of Agriculture under the auspices of the NC-83 Technical Committee, "Seed Production of Breeding Lines of Insect Pollinated Legumes."

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Several morphological and environmental variables have been correlated with alfalfa seed yield (Rumbaugh *et al.,* 11) by relating 18 plant characteristics in spaced nurseries in the North Central Region to seed yields of the same clones in California and Idaho. No independent variable was sufficiently associated with seed yields to satisfactorily predict seed yield potential in the western states. Independent variables that consistently generated relatively high standardized partial regression coefficients for predicting seed yield were: (a) number of racemes per plant, (b) flower color score, (c) number of stems per plant, (d) wet forage weight per plant, (e) percentage of fertile selfed florets, (f) number of open pollinated seeds per pod, and (g) number of coils per pod. The relative importance of some traits in equations for predicting second-year seed yields differed from those for the first year when propagules were transplanted.

Fryer (3) successfully used maternal line selection procedures to simultaneously select for forage and seed yields. His program used a continuous sequence of 4-year stands, each containing about 80 fifty-plant progenies from which he selected the most highly fertile and vegetatively superior plants. Applying that method 10 years, he developed a stock that produced significantly more seed than controls with no loss in hay yields.

Pedersen (9) noted that neither cross- nor self-fertility of 17 parental alfalfa clones indicated hay production of progenies. However, progeny seed production correlated with both cross-fertility and seed production of parents. Over 3 years, 9 selections based on maternal seed production were 39% superior in seed production to the average of 6 controls. Heinrichs (4) found no association between seed yield of parental clonal lines and their polycross progenies in different years or at two test locations in Saskatchewan. However, he developed an eight clone synthetic predicted to yield more seed at both locations than the source population while maintaining forage yield and winter hardiness of the source population.

Melton (6) polycrossed and intercrossed nine selected alfalfa clones in a diallel series under cages with honeybees. His progeny trials were with single row plots 2.43 m long with 0.61 m between rows. Forage and seed yields were not measured the same years. Most crosses yielded less than the polycross progeny of the parental clones. However, at least one cross in a group of crosses involving a given parent produced more seed or more forage than its corresponding progenies, particularly more seed. The correlation between progeny seed and forage yields was highly significant, $r=0.54$. The correlation between self-fertility of parent clones and forage yields of polycross progeny was not significant (—0.42) but that for seed yields was (—0.69).

MATERIALS AND METHODS

We established propagules of 30 alfalfa clones in multiple plant plots in replicated spaced nurseries near Lafayette, Ind.; Ames, Ia.; Manhattan, Kan.; Rosemount, Minn.; Lincoln, Neb.; Brookings, S. D.; and Fresno, Cal., in 1966, and near Caldwell, Idaho, in 1967 (11). Plants in California were pollinated by honey bees (*Apis mellifera* L.); those in Idaho, by leaf cutter bees (*Megachile rotundata* Fabricius). Open pollinated seed was harvested from each plot both the first and second years in both California and Idaho.[3]

Clonal progeny tests were planted in California, Iowa, Kansas, Nebraska, and South Dakota in 1968 and in Idaho in 1969. Seed for the 1968 trials was obtained by bulking equal quantities of the 1967 California open pollinated seed from each replication for each parental clone. Similarly, seed for the Idaho trial was from open pollinated seed produced in Idaho in 1968, with three grams from each of four replications bulked for each parental clone. Control varieties grown in the North Central Region were Atlantic, Buffalo, Dawson, Narragansett, Ranger, and Vernal. Only the last two were evaluated in California and Idaho.

Pre-plant herbicide was applied at all locations except Kansas to control weeds. Each test was spring sown with equipment customarily used at each location for forage or seed trials (Table 1).

Traits measured at one or more locations in the North Central Region included forage yield (oven dry tons/A), stand, spring growth habit, fall growth habit, rate of recovery after cutting, downy mildew (*Peronospora trifoliorum* de Bary) injury, leafhopper (*Empoasca fabae* Harris) injury, plant height, and winter injury. Stand was measured by counting either four- or six-inch intervals with no alfalfa plants in rows and converting to percentage of harvested row length (5). Spring and fall growth habits, rate of recovery after cutting, and downy mildew and leafhopper injury were scored on a one to nine scale as suggested by the "Report of the Committee on Genetics and Breeding Nomenclature," *Report of the Nineteenth Alfalfa Improvement Conference,* 1964 (Table 2).

Interpretations of the data were aided by analysis of variance and by simple and multiple correlation and regression of entry means for each location. Forward step-wise procedures were used when evaluating the predictive importance of two or more independent variables. The equation using all those variables is called the 'complete' equation in our discussion and

[3]The authors appreciate the cooperation of L. E. Arnold and H. L. Carnahan, Arnold-Thomas Seed Service, and of R. R. Kalton and D. E. Brown, Land O'Lakes, Inc., who made the California and Idaho trials possible.

tables. The equation for which the coefficient of multiple determination R^2 most closely approximated 0.80 is called the "terminal" equation, which corresponds with our earlier arbitrary usage of "terminal" to indicate an equation with sufficient predictive value to be of practical use in a breeding program. In some instances, inclusion of all available independent variables did not result in R^2 so large as 0.80. Complete and terminal equations then were identical. All correlations and regressions were computed with data for 29 clones and their progenies when possible. Information for the control cultivars and for one of the Indiana clones was not used because they were not uniformly included in all plantings all years. Winter mortality in the South Dakota, space-planted nursery limited computations involving 1967 clonal data to 20 of the parents or their progenies for that state.

Table 1. Summary of progeny forage and seed yield trials.

Location	Number of repli-cations	Plot size	Number of rows per plot	Seed planted per plot (g)	Dryland or irrigated
Iowa	3	30" x 15'	3	6.7	Dryland
Kansas	3	30" x 14'	3	6.7	Irrigated
Nebraska	3	27" x 15'	3	6.7	Irrigated
South Dakota	3	48" x 20'	4	6.7	Dryland
California	4	40" x 16'	1	1.0	Irrigated
Idaho	4	36" x 12'	2	1.0	Irrigated

RESULTS AND DISCUSSION

Progeny Trait Means and Simple Correlations

Initial stands in all progeny trials were excellent. First year forage yields were measured in Iowa, Kansas, and South Dakota. Irregular winter injury and stand loss during 1968-69 precluded valid yield comparisons in Nebraska. Seed yields were obtained in the first and second years in both western states. Other agronomic information collected is listed in Table 2. Information on each characteristic for each open pollinated progeny and control variety was pooled by averaging the data over locations and years (Tables 3 and 4).

Seed yields ranged from 288 to 589 pounds per acre. Ranger, known by seed growers to be productive, yielded highest. Differences among test entries in seed yield were significant ($P<0.05$). Forage yields ranged from 4.62 to 5.49 tons per acre, not significantly different on the basis of entry location—year averages. Means for other traits are shown for each entry but the data were not subjected to analysis of variance.

Simple correlations of yield averages of open pollinated progenies and their other traits are shown in Table 5. Data for control varieties were not included. Nine of the 14 traits were significantly associated with

Table 2. Locations and times traits of open pollinated progenies were measured.

Trait	State	Dates
Seed yield (lb/acre)	California	1968, 1969
	Idaho	1969, 1970
Forage yield (ton/acre)	Iowa	1968, 1969, 1970
	Kansas	1968, 1969, 1970
	South Dakota	1968, 1969, 1970
Stand (%)	Iowa	6-13-69, 6-16-70
	Kansas	11-22-68, 10-1-69, 11-18-70
	Nebraska	6-6-69
	South Dakota	8-18-69, 5-6-69, 5-19-70
Spring growth habit (score)	Kansas	4-19-69, 4-28-70
	Nebraska	4-27-70
	South Dakota	5-6-69, 5-19-70
Rate of recovery (score)	Iowa	1969 Cuts 1-3, 6-16-70
	Kansas	6-7-69, 7-15-69, 8-26-69, 10-1-69, 6-9-70, 7-9-70, 8-15-70, 9-18-70
	Nebraska	7-7-70
	South Dakota	8-8-70, 8-2-70
Fall growth habit (score)	Iowa	10-14-69
	Nebraska	10-1-69, 10-25-70
	South Dakota	9-15-69, 9-18-70
Plant height (in.)	Kansas	6-24-68, 9-24-68
Winter Injury (%)	Iowa	4-29-70
Downy mildew (score)	Kansas	6-24-68
Leafhopper injury (score)	South Dakota	9-10-68

Table 3. Yields, growth habits, and stand of open pollinated progenies and varieties averaged over locations and years.

Maternal clone or variety	Seed yield (lb/acre)	Oven dry forage yield (ton/acre)	Stand (%)	Spring growth habit (score)	Fall growth habit (score)
Ind. 62-235	412	4.80	94	4	4
Ind. 62-237	294	5.01	93	3	3
Ind. 48-55	324	4.87	89	5	4
Ind. 62-247	458	4.71	94	4	4
Ind. 62-267	399	4.85	88	4	3
Ia. 918-2	316	5.16	93	3	3
Ia. 918-3	403	5.14	94	4	4
Ia. 46-1	358	4.90	91	4	4
Ia. 1317	460	5.00	91	3	3
Ia. 1516	373	4.96	93	5	6
Kans. 2313	401	5.16	87	4	3
Kans. 2314	558	5.25	94	3	2
Kans. 2315	371	5.11	93	4	3
Kans. 2316	497	5.49	93	3	3
Kans. 2311	485	4.71	89	5	2
Minn. 247	485	4.67	87	5	6
Minn. 559	431	5.31	93	3	4
Minn. 589	481	5.22	96	2	3
Minn. 1166	363	4.70	93	4	5
Minn. 1221	481	4.83	89	4	5
Nebr. 661	446	4.97	95	4	4
Nebr. 662	528	5.07	94	3	3
Nebr. 663	557	5.26	95	4	4
Nebr. 664	288	5.27	95	2	3
Nebr. 665	492	5.16	94	3	2
S. D. 1108	462	5.01	95	5	5
S. D. H2-8	456	5.05	94	3	3
S. D. H2-7	309	4.62	92	5	5
S. D. CK 25-1	398	4.66	90	4	5
S. D. CK 27-1	322	4.76	91	4	4
Atlantic	--	4.97	94	3	2
Buffalo	--	4.89	92	3	3
Dawson	--	5.03	91	3	3
Narragansett	--	5.03	96	4	3
Ranger	589	4.81	93	3	3
Vernal	544	4.88	92	4	4
Mean	432	4.98	92	4	4
$^{w}(0.05)$	119	N.S.	-	-	-
C.V., %	21	15	-	-	-

Table 4. Rate of recovery after cutting, plant height, and injury traits of open pollinated progenies and varieties. Recovery and height values are averages over times and/or locations.

Maternal clone or variety	Rate of recovery (score)	Plant height (in)	Winter injury (%)	Downy mildew (score)	Leaf hopper (score)
Ind. 62-235	5	16.4	70	5	4
Ind. 62-237	5	16.5	52	5	3
Ind. 48-55	5	16.2	83	4	3
Ind. 62-247	5	15.6	50	3	3
Ind. 62-267	4	17.8	72	4	4
Ia. 918-2	5	16.6	60	4	3
Ia. 918-3	6	15.6	57	2	4
Ia. 46-1	4	16.8	77	3	6
Ia. 1317	5	17.8	72	2	4
Ia. 1516	7	15.5	68	2	3
Kans. 2313	3	17.5	75	5	3
Kans. 2314	4	17.8	52	5	3
Kans. 2315	4	17.0	62	2	3
Kans. 2316	3	18.0	63	4	3
Kans. 2311	4	16.5	86	6	8
Minn. 247	6	15.6	83	5	5
Minn. 559	5	15.4	67	3	3
Minn. 589	3	16.8	38	4	3
Minn. 1166	6	12.6	55	5	7
Minn. 1221	6	16.4	83	4	5
Nebr. 661	5	16.8	27	3	2
Nebr. 662	5	17.0	45	4	3
Nebr. 663	5	16.7	33	2	3
Nebr. 664	4	17.0	40	3	2
Nebr. 665	3	17.2	53	5	4
S.D. 1108	6	15.4	23	3	3
S.D. H2-8	4	16.3	50	5	5
S.D. H2-7	5	15.4	53	4	4
S.D. CK25-1	6	15.5	70	2	3
S.D. CK27-1	5	16.2	67	4	5
Atlantic	3	17.2	42	5	5
Buffalo	3	17.8	68	4	4
Dawson	4	16.3	60	5	4
Narragansett	4	17.2	32	2	4
Ranger	3	17.5	62	5	4
Vernal	5	16.3	58	4	3
Mean	5	16.5	59	4	4

forage yield. Highest coefficient was for spring growth habit—forage yield, $r=-.66$. Rate of recovery scores after cuttings one and two were next with —.61 and —.63 respectively.

Forage yield was the only North Central Region progeny trait significantly related to progeny seed yield. Although the coefficient of determination was not great ($r^2=.16$), it was positive, which supported the optimistic view that selecting for higher forage yields in the North Central Region might also indirectly give higher seed yields in western states. Another encouraging aspect was complete agreement in sign of all 14 pairs of correlation coefficients for forage and seed yields (Table 5). Negative signs result from assigning the most favorable aspect of a character the lowest score.

Forage and seed yields of progenies of the nine alfalfa clones tested in New Mexico were more closely associated than those in the North Central Region (Melton, 6). Melton's correlation coefficient was highly significant ($P<0.01$) 0.54 with a corresponding coefficient of determination of 0.29. His closer association may have come from measuring both forage and seed yields in the same test in different years. His wider spaced rows (0.61 m) also may have influenced the results. The data from both investigations suggest that alfalfa forage and seed yields can be improved simultaneously.

Predicting Progeny Seed Yield

1. **From clonal traits.** The relationships of seed yields from clones measured in each North Central Region test to seed yields of their open pollinated progenies measured in the western tests is described by simple correlation and linear regression (Table 6). The associations were not close, with only 6 of 36 correlation coefficients significant. The six were for Minnesota and Nebraska data. The highest coefficient was too low to have major value in selection programs ($r^2=.24$). Of correlations that differed significantly from zero, the four involving Nebraska were positive, whereas the two involving Minnesota were negative. A location effect is apparent, but the biological basis for the difference in sign is not understood. The results support those of Heinrichs (4) who found no association between seed yield of parental clones and their polycross progenies, which is further substantiated by lack of strong associations in the western states (Table 7). All of the eight simple correlation coefficients for California and Idaho were lower than those for Minnesota and Nebraska clonal data. None differed significantly from zero but six of the eight were positive.

Some coefficients (r) of yearly averages for all traits measured in the North Central Region clonal nurseries and of average open pollinated progeny seed yields in the western states were significant (Table 8):

Table 5. Simple correlations (r) of North Central Region progeny trait means with average progeny forage and seed yields.

	Progeny yields	
Progeny trait	Forage	Seed
Stand (%)	.46**	.11
Spring growth habit score	-.66**	-.18
Rate of recovery score - cut 1	-.61**	-.18
Rate of recovery score - cut 2	-.63**	-.25
Rate of recovery score - cut 3	-.51**	-.20
Rate of recovery score - cut 4	-.31	-.20
Fall growth habit score	-.51**	-.20
1968 South Dakota leaf hopper score	-.54**	-.20
6-24-68 Kansas plant height (in)	.30	.17
9-24-68 Kansas plant height (in)	.48**	.25
1970 Iowa winter injury (%)	-.35	-.20
1968 Kansas downy mildew score	-.14	-.13
North Central forage yield (dry t/a)	1.00**	.40*
Western states seed yield (lbs/a)	.40*	1.00**

* P <0.05
** P <0.01

Table 6. Simple correlation and regression relationships of seed yields of 29 clones in 5 North Central states and their open pollinated progeny yields in 2 western states.

Tests			Y = a + b X		
Clone (g/plant)	Progeny (lb/acre)	r	a	b	S.E.E.[1]
1966 Kans.	1968 Calif.	.03	495	1.75	87
	1969 Calif.	.18	390	8.95	65
	1969 Idaho	.24	492	19.92	105
	1970 Idaho	.12	325	5.46	61
1966 Minn.	1968 Calif.	-.08	513	- 6.39	86
	1969 Calif.	.17	377	9.55	65
	1969 Idaho	.05	503	5.11	108
	1970 Idaho	-.09	344	- 4.71	61
1966 Neb.	1968 Calif.	.18	474	6.22	85
	1969 Calif.	.25	376	6.65	64
	1969 Idaho	.49**	434	21.90	95
	1970 Idaho	.41*	394	10.20	56
1966 S.D.	1968 Calif.	.03	495	16.25	87
	1969 Calif.	.05	398	20.15	66
	1969 Idaho	.30	491	203.94	104
	1970 Idaho	.05	329	18.90	61
1967 Ind.	1968 Calif.	-.26	521	-24.26	85
	1969 Calif.	-.30	425	-21.66	63
	1969 Idaho	.01	512	1.69	110
	1970 Idaho	-.03	334	- 2.16	62
1967 Kans.	1968 Calif.	-.00	498	- .08	87
	1969 Calif.	.05	394	1.45	66
	1969 Idaho	-.06	529	- 2.73	108
	1970 Idaho	.06	326	1.28	61
1967 Minn.	1968 Calif.	-.37*	548	- 7.72	81
	1969 Calif.	-.19	421	- 3.10	65
	1969 Idaho	-.04	523	- 1.05	108
	1970 Idaho	-.37*	368	- 5.49	57
1967 Neb.	1968 Calif.	.17	476	4.57	86
	1969 Calif.	.28	374	5.70	63
	1969 Idaho	.39*	456	13.05	100
	1970 Idaho	.38*	299	7.08	57
1967 S.D.[2]	1968 Calif.	.05	491	3.75	75
	1969 Calif.	-.08	404	- 5.38	70
	1969 Idaho	.12	491	12.61	105
	1970 Idaho	.05	332	3.23	66

[1] Standard error of estimate
[2] Based on 20 clones that survived the 1966-67 winter

* $P < 0.05$
** $P < 0.01$

Table 7. Simple correlation and regression relationships of seed yields of 29 clones and their open pollinated progenies in 2 western states.

Tests			Y = a + b X		
Clone (g/plant)	Progeny (lb/acre)	r	a	b	S.E.E.[1]
1966 Calif.	1968 Calif.	.16	475	1.08	86
	1969 Calif.	.28	370	1.45	64
1967 Calif.	1968 Calif.	.19	472	1.10	85
	1969 Calif.	.29	370	1.27	63
1967 Idaho	1969 Idaho	.11	482	1.16	108
	1970 Idaho	-.16	358	- .89	60
1968 Idaho	1969 Idaho	.10	489	1.35	108
	1970 Idaho	-.07	342	- .51	61

[1] Standard error of estimate

Table 8. Simple correlations (r) of 1966 and 1967 North Central Region clonal trait means with average progeny seed yields.

	r	
Clonal trait	1966	1967
Date initial bloom	-.35	-.35
Number racemes per plant	.51**	-.21
Raceme length (mm)	.10	-.07
Raceme width (mm)	.02	-.01
Number florets per raceme	.04	.07
Flower color score	-.46*	-.36
Number stems per plant	.35	-.46*
Length longest stem (mm)	.07	-.19
Growth habit score	-.19	-.16
<u>X. alfalfae</u> damage score	.20	--
Wet forage weight per plant (g)	-.19	-.40*
Dry forage weight per plant (g)	-.08	-.43*
Fertile o.p. florets (%)	-.24	-.58**
Fertile selfed florets (%)	-.31	-.59**
Number o.p. seeds per pod	.36	.26
Number coils per pod	.54**	.43*
Seed weight per plant (g)	.09	-.06

* r differs significantly from zero ($P < 0.05$)
** r differs significantly from zero ($P < 0.01$)

first-year number of racemes per plant and first- and second-year number of coils per pod were positive; first-year flower color, second-year number of stems per plant, wet forage weight per plant, dry forage weight per plant, percentage of fertile open pollinated florets, and percentage of fertile selfed florets were all negative. The last one in 1967 was more closely associated with progeny seed yields than any other clonal trait averages but the coefficient of determination was low, r^2=.35.

Number of racemes per plant, flower color score, number of stems per plant, percentage of fertile open pollinated florets, and number of coils per pod significantly correlated with seed yield of those same clones in California and Idaho (11). Percentage of fertile open pollinated florets correlated positively for the clone—clone relationship but negatively for the clone—progeny relationship. Percentage of fertile selfed florets was not significantly related to seed yield of the 29 clones, but the 1967 fertilities were related to seed yield of open pollinated progenies of the same 29 clones (Table 8). Rumbaugh *et al.* (11), using the same germplasm, reported an average of 28 percent fertile selfed florets. Pedersen (9) found 86 percent cross and 35 percent self fertility with the 17 clones he investigated. Cross, but not self, fertility of parental clones was significantly correlated with seed yield of their progenies in his experiment. His association of cross fertility of clones with seed yield of progenies was positive (r=.48). The association was negative for both years we gathered clonal data.

A positive association of cross fertility and seed yield of progenies seems more logical than a negative association, but the relationship may depend on the germplasm or the environments used.

Forward step-wise multiple regression was used to predict seed yield in each of the first and second years of growth in California and Idaho and for each of the five North Central locations for which clonal data were available. Twenty-nine clones and their progenies were involved. Only 20 clones and their progenies were used in South Dakota because of mortality in the spaced nursery during 1966-67. Coefficients of multiple determination (R^2) for both the complete and the terminal regression are shown in Table 9.

Table 9. Summary of R^2 values for the complete and terminal equations predicting open pollinated-progeny seed yield from parental clone characteristics.

Source of independent variable data	Year and location of seed yield predicted			
	California			
	1968		1969	
	Complete	Terminal	Complete	Terminal
Indiana	.94 (23)[1]	.63 (5)	.85 (23)	.64 (7)
Iowa	.49 (12)	.49 (12)	.55 (12)	.55 (12)
Kansas	.86 (24)	.66 (8)	.94 (24)	.66 (8)
Minnesota	.84 (15)	.70 (7)	.68 (15)	.63 (10)
Nebraska	.71 (29)	.64 (12)	.71 (29)	.64 (10)
South Dakota	.73 (24)	.64 (7)	.65 (24)	.63 (16)
	Idaho			
	1969		1970	
	Complete	Terminal	Complete	Terminal
Indiana	.89 (23)	.63 (5)	.92 (23)	.64 (7)
Iowa	.51 (12)	.51 (12)	.46 (12)	.46 (12)
Kansas	.87 (24)	.63 (5)	.87 (24)	.64 (6)
Minnesota	.77 (15)	.63 (6)	.57 (15)	.57 (15)
Nebraska	.73 (29)	.63 (9)	.61 (29)	.61 (29)
South Dakota	.65 (24)	.64 (14)	.60 (24)	.60 (24)

[1] Numbers in parentheses are the number of independent variables measured in 1966 and 1967 and included in the equation.

Maximum correlation was found when predicting 1968 California seed yield from Indiana clonal data and 1969 California seed yield from Kansas clonal data. The Indiana function involved 23 independent variables and the Kansas function 24. As shown for terminal equations, many of the variables could be deleted with little loss of information. However, in no case did an equation with fewer than five independent variables meet the arbitrary requirement for a terminal equation (0.80). The inadequacy of North Central clonal data for predicting seed yield was apparent from the number of independent variables used in some equations and the low values for R^2 (Table 9). For example, including both 1966 and 1967 clonal data, 29 independent variables from Nebraska were used to predict 1970 Idaho open pollinated progeny seed yield, with a coefficient of multiple determination equal to only 0.61.

The individual step-wise regressions showed that only one or a few independent variables alone contributed significantly toward adequate predictive capability for four North Central states, judged by whether or not adding a clonal trait significantly reduced residual variance. The four states were Indiana, Iowa, Kansas, and Minnesota. In several equations for those states, only one independent variable was significant. The maximum significant number was six for Kansas data used to predict 1969 Idaho seed yields with R^2= .69. In contrast, South Dakota and especially Nebraska data required more variables to be fitted, before adding another variable did not significantly reduce residual variance. The maximum number was 11 Nebraska clonal traits to predict 1969 Idaho seed yields with R^2=.67.

No one character or group of clonal characters was uniform in all equations. Traits most strongly correlated with seed yields and the number of times they were included as step 1 in the 24 predictive equations in brackets follow: flower color score [4], percentage of fertile open pollinated florets [4], number of racemes per plant [3], length of longest stem [3], wet forage weight per plant [3], date of initial bloom [2], number of stems per plant [2], raceme width [1], number of coils per pod [1], and seed weight per plant [1].

All available information obtained for each clonal trait during the year plants were established (1966) was averaged and then used to predict mean western state seed yields of the progenies (Table 10). Number of coils per pod, percentage of fertile open pollinated florets, and growth habit score each explained a significant amount of variation in progeny seed yield.

Table 10. Summary of step-wise regression for predicting average California and Idaho progeny seed yields from means of clonal traits measured in the North Central Region in 1966.

Step No.	Variable entered	R	R^2
1	Number coils per pod	.53	.30
2	Fertile o. p. florets (%)	.63	.40
3	Growth habit score	.76	.57
-----	-----	-----	-----*
4	Wet forage weight per plant (g)	.79	.62
5	Raceme width (mm)	.81	.66
6	Raceme length (mm)	.83	.68
7	Number racemes per plant	.84	.71
8	Number florets per raceme	.85	.73
9	*X. alfalfae* damage score	.87	.76
10	Number o. p. seeds per pod	.91	.83
11	Dry forage weight per plant (g)	.91	.83
12	Date initial bloom	.92	.84
13	Seed weight per plant (g)	.92	.84
14	Flower color score	.92	.85
15	Fertile selfed florets (%)	.92	.85
16	Number stems per plant	.92	.85
17	Length longest stem (mm)	.92	.85

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

Table 11. Summary of step-wise regression for predicting average California and Idaho progeny seed yields from means of clonal traits measured in the North Central Region in 1967.

Step No.	Variable entered	R	R^2
1	Fertile selfed florets (%)	.59	.35
2	Number stems per plant	.70	.49
3	Number o. p. seeds per pod	.80	.64
4	Fertile o. p. florets (%)	.87	.76*
5	Flower color score	.88	.78
6	Growth habit score	.90	.81
7	Number coils per pod	.91	.83
8	Dry forage weight per plant (g)	.92	.84
9	Raceme length (mm)	.92	.86
10	Date initial bloom	.93	.86
11	Wet forage weight per plant (g)	.93	.86
12	Length longest stem (mm)	.93	.87
13	Raceme width (mm)	.93	.87
14	Number florets per raceme	.93	.87
15	Seed weight per plant (g)	.94	.87
16	Number racemes per plant	.94	.87

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

When all 17 independent traits were included in the predictive equation, 15 percent of the seed yield variance remained unexplained. The same process was followed with the 1967 North Central clonal data (Table 11). Each of four independent variables significantly reduced residual variance. Percentage of fertile open pollinated florets ranked fourth as a predictor and none of the other three characters was the same as the more important traits indicated by analysis of 1966 data. Using the 15 independent variables listed in Table 11, 13 percent of the variation in progeny seed yields was due to deviations from levels expected on the basis of complete multiple regression.

Comparing information in Tables 10 and 11 is both disturbing and reassuring. For example, percentage of fertile, open-pollinated florets was important in both analyses, yet percentage of fertile selfed florets was incorporated into the function as step 15 or 17 for the 1966 data but as step 1 of 16 for the 1967 data. Biological bases for such wide variance are not understood. Considering all available predictive information and empirical knowledge of the relative difficulty and costs of measuring variables, we concluded that progeny seed yield in the western states may be predicted best from North Central spaced clonal nursery data on date initial bloom, flower color score, growth habit score, percentage of fertile, open-pollinated florets, and number of coils per pod. Considering those 5 traits in step-wise regression with 1966 data alone, 1967 data alone, and then with data combined for both years (10 independent variables), we obtained R^2 values of 0.59, 0.52, and 0.73, respectively, for the 3 complete equations. In each case, percentage of fertile, open-pollinated florets and number of coils per pod were included in the first two steps of the process, *i.e.,* they were better predictors of progeny seed yield than other traits.

2. **From progeny traits.** The only North Central progeny trait average significantly correlated with average seed yield in the western states was forage yield (r=.40, Table 5). Data from each of the four progeny trial locations were examined individually to predict seed yield measured in each year and location in the two western states. Coefficients of multiple determination and the number of independent variables entering complete and terminal equations are presented in Table 12. The range of R^2 for the complete equations was from 0.87, using 19 Kansas variables to predict 1969 Idaho seed yield, to 0.15, using 6 Nebraska variables to predict 1968 California seed yield. Because forage yield data were not available from the Nebraska test, as stands were lost, the four complete equations for that location were expected to give lower R^2 values than data from the other three tests.

Table 12. Summary of R^2 values for the complete and terminal equations predicting open pollinated progeny seed yield from progeny vegetative characteristics.

Source of independent variable data	Year and location of seed yield production			
	California			
	1968		1969	
	Complete	Terminal	Complete	Terminal
Iowa	.42 (11)[1]	.42 (11)	.44 (11)	.44 (11)
Kansas	.81 (19)	.67 (7)	.73 (19)	.64 (8)
Nebraska	.15 (6)	.15 (6)	.21 (6)	.21 (6)
South Dakota	.49 (12)	.49 (12)	.62 (12)	.62 (12)
	Idaho			
	1969		1970	
	Complete	Terminal	Complete	Terminal
Iowa	.28 (11)	.28 (11)	.54 (11)	.54 (11)
Kansas	.87 (19)	.68 (6)	.78 (19)	.66 (9)
Nebraska	.27 (6)	.27 (6)	.28 (6)	.28 (6)
South Dakota	.47 (12)	.47 (12)	.30 (12)	.30 (12)

[1] Numbers in parentheses are the number of independent variables measured in 1968, 1969, and 1970 and included in the equation.

Table 13. Summary of step-wise regression for predicting average California and Idaho progeny seed yields from means of progeny traits measured in the North Central Region.

Step No.	Variable entered	R	R^2
1	Forage yield (dry tons/acre)	.40	.16
----------	----------	----------	----------*
2	Spring growth habit score	.42	.18
3	Rate of recovery score - cut 4	.43	.19
4	Rate of recovery score - cut 1	.46	.21
5	1970 Iowa winter injury (%)	.46	.21
6	9-24-68 Kansas plant height (in)	.48	.23
7	1968 Kansas downy mildew score	.49	.24
8	Stand (%)	.49	.24
9	1968 South Dakota leaf hopper score	.50	.25
10	Rate of recovery score - cut 3	.50	.25
11	6-24-68 Kansas plant height (in)	.50	.25
12	Fall growth habit score	.50	.25
13	Rate of recovery score - cut 2	.50	.25

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

Table 14. Simple correlations (r) of 1966 and 1967 North Central Region clonal trait means with average progeny forage yields.

Clonal traits	r	
	1966	1967
Date initial bloom	-.46*	-.20
Number racemes per plant	.43*	.03
Raceme length (mm)	-.10	.16
Raceme width (mm)	.11	.15
Number florets per raceme	-.12	.11
Flower color score	-.17	-.20
Number stems per plant	.64**	-.05
Length longest stem (mm)	.09	.06
Growth habit score	-.38*	-.46*
X. alfalfae damage score	.08	--
Wet forage weight per plant (g)	.10	.00
Dry forage weight per plant (g)	.31	-.32
Fertile o.p. florets (%)	-.43*	-.39*
Fertile selfed florets (%)	-.21	-.58**
Number o.p. seeds per pod	.09	.20
Number coils per pod	.40*	.40*
Seed weight per plant (g)	.12	.13

* r differs significantly from zero ($P < 0.05$)
** r differs significantly from zero ($P < 0.01$)

Forage yield expressed as dry tons per acre was the best predictor in 5 of the 16 North Central state equations for western state—year seed yields. In step one of the remaining equations, three included 1969 fall growth habit, three included rate of recovery, and three included stand percentage. No single variable measured in Iowa significantly correlated with 1969 Idaho seed yields. Similarly, no single variable measured in South Dakota significantly correlated with 1970 Idaho seed yields. In the five instances that progeny forage yield was the best available predictor trait, all used 1968 data and four used Kansas data. The fifth involved 1968 forage yields from South Dakota. Expression of vegetative vigor the year plots were established in the North Central Region, may therefore be one of the better criteria for assessing potential performance of alfalfa germplasm for seed production. That interpretation was strengthened when means of progeny traits were entered in stepwise regression to predict seed yield (Table 13). Forage yield was the only trait that, considered alone, significantly reduced the residual sum of squares.

Although the progeny traits measured in the North Central Region did not precisely predict seed yields in the western states, the results were encouraging. Forage yield, stand, rate of recovery, and fall growth habit score all are either routinely measured on progenies in alfalfa breeding programs or can be incorporated readily into the procedures. Essentially, it appears that genotypes sufficiently winter hardy to maintain stand and vigor, recover rapidly after cutting, and produce high forage yields and also are inherently capable of maximum seed yields.

3. **From clonal and progeny traits.** Progeny information was combined first with 1966 clonal trait means and then with 1967 clonal trait means in multiple regression equations predicting average progeny seed yields. Little advantage was apparent over using only clonal independent variables. *R* for the complete equation including 1966 data was .97 compared with .92 (Table 10). *R* was also .97 for the 1967 equation compared with .94 (Table 11). Furthermore, no variables other than those in Tables 10 and 11 significantly reduced the residual variance. Therefore, we conclude that clonal data are sufficient to predict western state seed yields of alfalfa progenies. Precision was increased little by incorporating open-pollinated progeny data from the North Central Region with the clonal information.

Predicting Progeny Forage Yields

1. **From clonal traits.** Simple correlation coefficients for 1966 and 1967 clonal trait means with average progeny forage yields in the North Central Region are listed in Table 14. Differences in associations with yield and traits measured during the two years are readily apparent. The smaller size and varied development of clonal propagules transplanted to the field in 1966 undoubtedly increased phenotypic variance

Table 15. Simple correlation and regression relationships of forage yields of 29 clones and their open pollinated progenies in 3 North Central States.

Tests			Y = a + b X		
Clone[1] (g/plant)	Progeny (Tons/acre)	r	a	b	S.E.E.[2]
1966 Kans.	1968 Kans.	.34	5.3	.01	.47
	1969 Kans.	-.04	10.0	-.00	.68
	1970 Kans.	-.10	9.6	-.00	.59
1966 S.D.	1968 S.D.	.17	1.0	.00	.10
	1969 S.D.	.24	5.4	.00	.31
	1970 S.D.	.11	4.1	.00	.28
1967 Iowa	1968 Iowa	.32	2.3	.00	.13
	1969 Iowa	-.09	4.1	-.00	.30
	1970 Iowa	.28	2.1	.00	.38
1967 Kans.	1968 Kans.	-.07	6.0	-.00	.50
	1969 Kans.	-.26	10.5	-.00	.66
	1970 Kans.	-.26	9.9	-.00	.57
1967 S.D.[3]	1968 S.D.	-.16	1.1	-.00	.12
	1969 S.D.	.22	5.5	.00	.31
	1970 S.D.	-.31	4.3	-.00	.25

1 1966 Clone - dry grams/plant
1967 Clone - wet grams/plant
2 Standard error of estimate.
3 Based on 20 clones that survived the 1966-67 winter.

among clones that year. The 1967 coefficients are more representative of well established clonal nurseries, as previously discussed (11). Growth habit score, percentage of fertile, open-pollinated florets, and number of coils per pod measured both years were significantly associated with open-pollinated progeny, forage yields of the clones. Forage weight of propagules did not correlate with forage yield of progenies; the coefficient was negative for the 1967 data. Fertility of both open and self pollinated florets in 1967 was significantly and negatively correlated with forage yield of progenies. The association with number of coils per pod was positive. Coefficients for clonal seed production in the North Central Region did not differ significantly from zero.

Simple linear regression and correlation statistics based on clone and progeny top growth each year in each state are in Table 15. In no case did the correlation differ significantly from zero, but 8 of the 15 cases were negative. This substantiates earlier investigations in which data from spaced plantings did not reliably indicate forage yield potential in solid seeded stands (1, 8, 10, 12, 13). Our coefficients of multiple determination using all clonal information from each state in step-wise regressions with annual forage yields in the same states of pogenies for three test years are in Table 16. Kansas data were more reliable than those of South Dakota or Iowa. R^2 values for Kansas data for the complete equations were larger and the number of independent variables required for terminal equations were fewer than for Iowa or South Dakota. Relative importance of independent variables shifted from year to year using Kansas equations for example, three independent clonal variables individually reduced residual variance significantly when predicting progeny forage yields in 1968 in Kansas. The three, in order of importance were: 1966 number of racemes per plant, 1967 number of coils per pod, and 1966 percentage of fertile, open-pollinated florets. When regressing the 1969 forage yields, comparable independent variables were: 1966 percentage of fertile, open-pollinated florets and 1967 date of initial bloom. For 1970 forage yield, the variables were: 1967 percentage of fertile, open-pollinated florets, 1967 wet forage weight per

Table 16. Summary of R^2 values for the complete and terminal equations predicting open pollinated progeny forage yields in three states from parental clone characteristics in the same locations.

Source of independent and dependent variable data	1968 Complete	1968 Terminal	1969 Complete	1969 Terminal	1970 Complete	1970 Terminal
Iowa	.26 (12)[1]	.26 (12)	.49 (12)	.49 (12)	.72 (12)	.64 (9)
Kansas	.96 (24)	.74 (3)	.91 (24)	.65 (5)	.94 (24)	.65 (3)
South Dakota	.75 (24)	.64 (5)	.69 (24)	.64 (10)	.51 (24)	.51 (24)

Year of progeny test.

[1] Numbers in parentheses are the number of independent variables measured and included in the equation.

Table 17. Summary of step-wise regression for predicting average North Central Region progeny forage yields from means of clonal traits measured in 1966.

Step No.	Variable entered	R	R^2
1	Number of stems per plant	.64	.41
2	Fertile o.p. florets (%)	.71	.50
3	Flower color score	.75	.56
4	Number coils per pod	.82	.67
-----	-----	-----	-----*
5	Number florets per raceme	.85	.72
6	Number o.p. seeds per pod	.87	.76
7	Number racemes per plant	.88	.77
8	Dry forage weight per plant (g)	.89	.79
9	Date initial bloom	.91	.83
10	Growth habit score	.92	.84
11	Wet forage weight per plant (g)	.92	.84
12	Raceme width (mm)	.92	.85
13	Length longest stem (mm)	.92	.85
14	Seed weight per plant (g)	.92	.85
15	Fertile selfed florets (%)	.92	.86
16	*X. alfalfae* damage score	.92	.86
17	Raceme length (mm)	.92	.86

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

plant, and 1966 number of open-pollinated seeds per pod. The most consistent clonal trait in the three cases was percentage of fertile, open-pollinated florets although it varied by order of entry and by year (1966 or 1967). A location effect was obvious because percentage of fertile, open-pollinated florets was less important in all three South Dakota predictive situations and in two of three in Iowa. Other research in Utah provided evidence that neither cross nor self fertility of parent clones significantly correlated with hay yield of their progenies (9).

All available information obtained for each clonal trait during the year clones were established (1966) was averaged and then used to predict the mean North Central Region forage yields of the progenies (Table 17). The maximum value of R^2 for the complete equation with 17 independent variables was 0.86. Each of the variables significantly reduced residual variance. The same computations with 1967 clonal information were less successful (Table 18). R^2 for the complete equation was lower than for 1966 independent variable data, R^2=.67, and only two of the variables alone significantly reduced error variance. The more important characters in the two predictive situations did not correspond.

Better agreement came from comparing results of clonal data to predict seed yield and then predicting forage yield. Number of coils per pod and percentage of fertile, open-pollinated florets in 1966 were among the significant independent variables in both cases (Tables 10 and 17). Likewise, 1967 percentage of fertile selfed florets was the single most valuable predictive trait for both western state progeny seed yield and North Central progeny forage yield (Tables 11 and 18). The five clonal traits previously suggested as suited for predicting progeny seed yield, used to predict North Central progeny forage yield, gave R^2 values for 1966 data of 0.51; for 1967 data, 0.50; and for both years (10 independent variables), 0.73. These values agree well with those for seed yield equations. Orders of entry for seed yield and forage yield did not agree. However, the characters (date initial bloom, flower color score, growth habit score, percent fertile open pollinated florets, and number of coils per pod) are relatively easy and inexpensive to measure. They are among the more important spaced-plant clonal traits for predicting both progeny forage and progeny seed yields, so using them should prove beneficial in alfalfa breeding programs.

Table 18. Summary of step-wise regression for predicting average North Central Region progeny forage yields from means of clonal traits measured in 1967.

Step No.	Variable entered	R	R^2
1	Fertile selfed florets (%)	.58	.33
2	Growth habit score	.68	.46
----------	----------	----------	----------*
3	Date inital bloom	.73	.53
4	Number o.p. seeds per pod	.75	.56
5	Raceme width (mm)	.75	.57
6	Fertile o.p. florets (%)	.76	.58
7	Number florets per raceme	.77	.59
8	Wet forage weight per plant (g)	.78	.61
9	Raceme length (mm)	.79	.62
10	Seed weight per plant (g)	.80	.63
11	Flower color score	.80	.64
12	Number racemes per plant	.81	.66
13	Number stems per plant	.82	.67
14	Length longest stem (mm)	.82	.67
15	Number coils per pod	.82	.67
16	Dry forage weight per plant (g)	.82	.67

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

2. **From progeny traits.** Progeny characteristics other than forage yield were used to predict forage yield for each test year. Data were obtained in Iowa, Kansas, and South Dakota. Coefficients of multiple determination and numbers of independent variables used in the complete and terminal equations are in Table 19. The most efficient equation was the one with Iowa data used to predict 1970 progeny yields in Iowa. With only one independent variable, 1970 stand percentage, r^2=.79. Two additional variables accounted for significant variation among entry yields: 1970 rate of recovery following first cut and 1970 winter injury percentage. Other characteristics important in at least one of the step-wise regressions were spring growth habit score, fall growth habit score, rate of recovery following fourth harvest, and plant height in September.

Results from averaging all available information for each attribute of the progenies and conducting step-wise regression analysis are as summarized in Table 20. R^2 for the complete equation with 12 independent variables was 0.73. Only the first three steps included variables that by themselves significantly reduced the error mean square. The first two (spring growth habit score and rate of recovery after the first cut) were expected to be included because they had been important in previous analyses (Table 19). The next step (1968 South Dakota leaf hopper damage) was not anticipated. That character was included in step 10 when predicting the 1968 South Dakota progeny forage yields, in step 5 for 1969 yields, and in step 4 for 1970 yields. In no instance did it alone explain a significant proportion of the variance in yield of entries in South Dakota. Correlations of leaf hopper damage with average forage yields were —0.71 for Iowa, —0.30 for Kansas, and —0.39 for South Dakota. Leaf hopper damage being step three of the regression resulted primarily from its strong association with yield in Iowa. The biotic factors for the relationship are not known.

Average forage yields of the 29 progenies in each of the three states did not correlate well. Coefficients were (a) Iowa-Kansas, *r*=.42, (b) Iowa-South Dakota, *r*=.41, and (c) Kansas-South Dakota, *r*=.09. Because of the relatively low coefficients of multiple determination and lack of agreement on the importance of the independent variables in the predictive equations for each of the three North Central states where yield trials were conducted, we conclude that there is no adequate substitution for forage yield trials to estimate forage productivity at the locations. In addition, alfalfa yields at one location do not reliably predict potential yields at another location.

3. **From clonal and progeny traits:** Using both clone and progeny independent variables to predict average forage yield was more precise than using either one alone. The 1966 clonal data, plus progeny information, resulted in *R*=.99 in contrast to *R*=.92 for the clonal traits alone (Table 17) and *R*=.85 for progeny traits alone (Table 20). Similarly, 1967 clonal data, plus progeny variables, resulted in *R*=.98, while clonal traits alone gave *R*=.82 (Table 18). In both equations using the two sources of information to predict progeny forage yields, progeny mean spring-growth-habit score was most important and clonal mean date of initial bloom, the next most important.

Table 19. Summary of R^2 values for the complete and terminal equations predicting open pollinated progeny forage yields in three states from progeny characteristics other than yield.

Source of independent and dependent variable data	Year of progeny test					
	1968		1969		1970	
	Complete	Terminal	Complete	Terminal	Complete	Terminal
Iowa	.37 (7)[1]	.37 (7)	.62 (7)	.62 (7)	.86 (7)	.79 (1)
Kansas	.70 (16)	.64 (5)	.76 (16)	.63 (2)	.62 (16)	.62 (16)
South Dakota	.67 (10)	.64 (8)	.53 (10)	.53 (10)	.57 (10)	.57 (10)

[1] Numbers in parentheses are the number of independent variables measured and included in the equation.

Table 20. Summary of step-wise regression for predicting average North Central Region progeny forage yields from means of progeny traits other than yield.

Step No.	Variable entered	R	R^2
1	Spring growth habit score	.66	.43
2	Rate of recovery score - cut 1	.73	.54
3	1968 South Dakota leaf hopper score	.80	.64
-------	-------	-------	-------*
4	Rate of recovery score - cut 2	.82	.66
5	Stand (%)	.82	.68
6	9-24-68 Kansas plant height (in)	.83	.69
7	Fall growth habit score	.84	.70
8	1968 Kansas downy mildew score	.84	.71
9	1970 Iowa winter injury (%)	.85	.72
10	Rate of recovery score - cut 3	.85	.72
11	6-24-68 Kansas plant height (in)	.85	.72
12	Rate of recovery score - cut 4	.85	.73

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

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Table 21. Means of characters measured in 1968 on the open pollinated progenies and control varieties grown in Iowa.

Maternal clone or variety	Oven dry forage yield 2 cuts
Ind. 62-235	2.36
Ind. 62-237	2.30
Ind. 48-55	2.29
Ind. 62-247	2.51
Ind. 62-267	2.40
Ia. 918-2	2.64
Ia. 918-3	2.49
Ia. 46-1	2.22
Ia. 1317	2.71
Ia. 1516	2.72
Kans. 2313	2.38
Kans. 2314	2.50
Kans. 2315	2.36
Kans. 2316	2.62
Kans. 2311	2.12
Minn. 247	2.48
Minn. 559	2.57
Minn. 589	2.27
Minn. 1166	2.39
Minn. 1221	2.50
Nebr. 661	2.49
Nebr. 662	2.57
Nebr. 663	2.36
Nebr. 664	2.47
Nebr. 665	2.48
S.D. 1108	2.52
S.D. H2-8	2.38
S.D. H2-7	2.50
S.D. CK25-1	2.37
S.D. CK27-1	2.43
Atlantic	2.07
Buffalo	2.17
Dawson	2.29
Narragansett	2.48
Ranger	2.41
Vernal	2.39
Mean	2.42
$w_{.05}$	.24
C.V., %	6

Table 22. Means of characters measured in 1969 on the open pollinated progenies and control varieties grown in Iowa.

Maternal clone or variety	Stand 6-13-69	Recovery rate[1] Cut 1	Cut 2	Cut 3	Fall growth habit[2] 10-14-69	Oven dry forage yield 4 cuts
	(%)	(score)			(score)	(t/a)
Ind. 62-235	95	4	4	5	4	4.11
Ind. 62-237	95	4	4	5	3	4.00
Ind. 48-55	99	6	5	5	4	4.10
Ind. 62-247	96	4	5	6	3	4.03
Ind. 62-267	94	2	2	3	2	4.04
Ia. 918-2	97	4	4	5	3	4.16
Ia. 918-3	95	4	6	6	4	4.09
Ia. 46-1	97	6	4	5	4	3.67
Ia. 1317	95	5	5	5	3	3.89
Ia. 1516	96	6	6	8	4	4.30
Kans. 2313	97	2	2	3	2	4.35
Kans. 2314	97	2	2	3	2	4.61
Kans. 2315	99	4	2	4	2	4.41
Kans. 2316	96	2	2	2	2	4.43
Kans. 2311	94	4	4	4	3	3.39
Minn. 247	91	6	6	7	5	3.82
Minn. 559	98	4	4	4	3	4.18
Minn. 589	99	4	2	4	3	4.18
Minn. 1166	97	6	7	6	5	3.79
Minn. 1221	97	5	6	7	4	3.68
Nebr. 661	96	3	2	4	4	3.78
Nebr. 662	97	6	4	5	4	3.67
Nebr. 663	97	2	2	4	3	4.22
Nebr. 664	98	4	2	2	2	4.40
Nebr. 665	98	3	2	2	1	4.38
S.D. 1108	97	4	6	6	3	3.97
S.D. H2-8	97	4	3	4	2	4.36
S.D. H2-7	95	6	4	6	5	3.73
S.D. CK25-1	94	6	6	6	4	3.65
S.D. CK27-1	94	5	5	6	3	3.94
Atlantic	96	1	1	1	1	4.32
Buffalo	98	2	3	4	3	4.40
Dawson	96	2	2	2	3	3.99
Narragansett	99	2	3	3	2	4.54
Ranger	96	4	2	4	3	4.00
Vernal	98	4	4	6	3	4.07
Mean	96	4	4	5	3	4.08
$w_{(0.05)}$	7	4	4	3	2	.33
C.V., %	2	30	32	24	22	5

[1] 1 = rapid recovery; 9 = slow recovery
[2] 1 = upright; 9 = postrate

Table 23a. Means of characters measured in 1970 on the open pollinated progenies and control varieties grown in Iowa.

Maternal clone or variety	% Winter injury[1] 4-29	% Stand[2] 6-16	Recovery rating 6-16
Indiana 62-235	70.0	66.0	4.3
Indiana 62-237	51.7	62.0	5.0
Indiana 48-55	83.3	49.0	7.7
Indiana 62-247	50.0	68.7	5.3
Indiana 62-267	71.7	47.7	6.3
Iowa 918-2	60.0	56.7	6.0
Iowa 918-3	56.7	67.7	5.2
Iowa 46-1	76.7	50.0	4.3
Iowa 1317	71.7	50.0	6.3
Iowa 1516	68.3	64.3	9.0
Kansas 2313	75.0	42.0	4.0
Kansas 2314	51.7	72.0	3.7
Kansas 2315	61.7	75.0	4.3
Kansas 2316	63.3	64.7	3.3
Kansas 2311	86.3	31.3	6.3
Minnesota 247	83.3	44.7	6.0
Minnesota 559	66.7	58.3	5.7
Minnesota 589	38.3	82.7	3.3
Minnesota 1166	55.0	63.3	6.0
Minnesota 1221	83.3	49.7	7.0
Nebraska 661	26.7	81.0	4.3
Nebraska 662	45.0	68.7	6.3
Nebraska 663	33.3	85.0	5.0
Nebraska 664	40.0	72.7	4.3
Nebraska 665	53.3	79.7	3.0
South Dakota 1108	23.3	81.7	3.7
South Dakota H2-8	50.0	73.0	3.0
South Dakota H2-7	53.3	67.3	5.7
South Dakota CK25-1	70.0	53.3	5.3
South Dakota CK27-1	66.7	58.0	5.0
Atlantic	41.7	73.0	2.3
Buffalo	68.3	57.0	3.7
Dawson	60.0	70.0	3.3
Narragansett	31.7	81.3	1.7
Ranger	61.7	67.7	4.3
Vernal	58.3	64.0	5.0
Experiment mean	58.6	63.9	4.9
L.S.D. (0.05)		17.6	2.7
(0.01)		23.4	3.5
C.V., %		16.9	33.6

[1] Visual estimate that reflects both loss of plants and reduced vigor.
[2] Some stand loss may have occurred the previous summer.
Stand percentage was determined by measuring gaps greater than 4 inches.

Table 23b. Means of characters measured in 1970 on the open pollinated progenies and control varieties grown in Iowa.

Maternal clone or variety	Yield of Dry Matter (T/A) 6-4	7-2	8-11	9-22	Total
Indiana 62-235	.96	.33	.55	.47	2.31
Indiana 62-237	1.07	.34	.58	.48	2.46
Indiana 48-55	.71	.21	.49	.39	1.80
Indiana 62-247	1.23	.37	.61	.49	2.70
Indiana 62-267	.84	.30	.54	.42	2.10
Iowa 918-2	1.10	.32	.59	.48	2.49
Iowa 918-3	1.26	.38	.59	.48	2.72
Iowa 46-1	.97	.26	.58	.46	2.27
Iowa 1317	.95	.26	.56	.46	2.23
Iowa 1516	.86	.19	.50	.36	1.92
Kansas 2313	.78	.28	.57	.45	2.07
Kansas 2314	.91	.33	.61	.61	2.46
Kansas 2315	1.08	.39	.66	.62	2.76
Kansas 2316	.98	.38	.70	.61	2.68
Kansas 2311	.68	.18	.46	.30	1.58
Minnesota 247	.78	.23	.51	.39	1.92
Minnesota 559	1.06	.31	.59	.47	2.43
Minnesota 589	1.29	.36	.62	.56	2.82
Minnesota 1166	.94	.23	.54	.40	2.11
Minnesota 1221	.81	.23	.51	.44	1.99
Nebraska 661	1.24	.45	.69	.58	2.96
Nebraska 662	1.04	.32	.58	.50	2.45
Nebraska 663	1.37	.43	.66	.65	3.11
Nebraska 664	1.14	.35	.62	.65	2.76
Nebraska 665	1.14	.43	.66	.63	2.86
South Dakota 1108	1.36	.52	.75	.60	3.23
South Dakota H2-8	1.11	.41	.65	.63	2.80
South Dakota H2-7	1.15	.33	.54	.50	2.53
South Dakota CK25-1	.88	.27	.51	.44	2.10
South Dakota CK27-1	.92	.29	.53	.48	2.22
Atlantic	1.07	.35	.64	.60	2.66
Buffalo	.82	.28	.57	.54	2.22
Dawson	1.01	.36	.66	.52	2.55
Narragansett	1.28	.44	.75	.64	3.12
Ranger	1.06	.32	.53	.50	2.41
Vernal	.97	.31	.59	.47	2.32
Experiment mean	1.02	.33	.59	.51	2.45
L.S.D. (0.05)	.32	.12	.13	.13	.61
(0.01)	.42	.17	.17	.17	.81
C.V., %	19.2	23.3	13.7	15.5	30.6

Table 24. Means of characters measured in 1968 on the open pollinated progenies and control varieties grown in Kansas.

Maternal clone or variety	Stand 1968	Downy Mildew[1]	Height 6-24	Height 9-24	Oven dry forage yield Cut 1	Cut 2	Cut 3	Cut 4	Total
	(%)	(score)	(inches)				(t/a)		
Ind. 62-235	99	4.7	22.7	10.0	1.55	1.58	1.38	0.93	5.44
Ind. 62-237	99	5.0	23.0	10.0	1.43	1.67	1.24	0.96	5.30
Ind. 48-55	99	4.0	22.3	10.0	1.73	1.82	1.49	1.07	6.11
Ind. 62-247	100	2.7	23.3	8.0	1.55	1.66	1.20	0.80	5.21
Ind. 62-267	100	3.7	24.0	11.7	1.57	1.83	1.28	1.08	5.76
Iowa 918-2	100	4.0	23.0	10.3	1.63	1.98	1.51	1.06	6.18
Iowa 918-3	99	2.0	23.0	8.3	1.79	1.84	1.33	0.91	5.87
Iowa 46-1	99	2.7	23.0	10.7	1.58	1.71	1.51	1.06	5.86
Iowa 1317	100	2.3	25.0	10.7	1.91	1.96	1.48	1.11	6.46
Iowa 1516	99	2.0	23.3	7.7	1.76	1.89	1.34	0.87	5.86
Kans. 2313	98	4.7	23.3	11.7	1.53	1.64	1.48	1.29	5.94
Kans. 2314	98	5.0	23.3	12.3	1.80	1.91	1.68	1.32	6.71
Kans. 2315	99	2.3	24.7	9.3	1.80	2.00	1.58	1.10	6.48
Kans. 2316	99	4.0	24.7	11.3	1.79	1.86	1.71	1.26	6.62
Kans. 2311	100	6.0	21.3	11.7	1.49	1.72	1.54	1.26	6.01
Minn. 247	98	5.0	23.0	8.3	1.40	1.62	1.13	0.80	4.95
Minn. 559	100	3.3	21.0	9.7	1.87	2.03	1.52	1.08	6.50
Minn. 589	100	4.0	22.7	11.0	1.63	1.78	1.61	1.01	6.03
Minn. 1166	99	5.0	17.0	8.3	1.58	1.81	1.30	0.80	5.49
Minn. 1221	100	4.0	24.0	8.7	1.71	1.83	1.37	0.80	5.71
Nebr. 661	100	3.0	24.7	9.0	1.90	1.81	1.36	0.93	6.00
Nebr. 662	100	3.7	24.3	9.7	1.97	1.98	1.49	1.09	6.53
Nebr. 663	99	2.3	23.7	9.7	1.74	1.89	1.46	1.05	6.14
Nebr. 664	99	3.3	24.0	10.0	1.92	1.89	1.62	1.17	6.60
Nebr. 665	100	4.7	23.3	11.0	1.54	1.60	1.42	1.03	5.59
S.D. 1108	100	3.0	23.0	7.7	1.58	1.86	1.37	0.75	5.56
S.D. H2-8	99	5.0	23.3	9.3	1.68	1.85	1.32	0.90	5.75
S.D. H2-7	98	4.0	22.7	8.0	1.52	1.68	1.24	0.80	5.24
S.D. CK25-1	100	2.3	23.0	8.0	1.73	1.75	1.22	0.80	5.50
S.D. CK27-1	99	4.0	24.0	8.3	1.45	1.61	1.26	0.86	5.18
Atlantic	100	5.3	24.0	10.3	1.61	1.85	1.42	1.04	5.92
Buffalo	100	4.3	23.3	12.3	1.49	1.72	1.67	1.11	5.99
Dawson	99	5.3	23.3	9.3	1.70	1.75	1.45	0.90	5.80
Narragansett	100	2.3	24.0	10.3	1.71	1.81	1.36	0.94	5.82
Ranger	100	5.3	24.0	11.0	1.60	1.63	1.43	1.01	5.67
Vernal	100	3.7	23.3	9.3	1.63	1.82	1.39	0.95	5.79
L.S.D. at 0.05									0.50
L.S.D. at 0.01									0.66
C.V., %									5.23

[1] Rated as 1 = no damage to 9 = severe damage.

Table 25a. Means of characters measured in 1969 on the open pollinated progenies and control varieties grown in Kansas.

Maternal clone or variety	Spring growth habit[1]	Recovery rate[1]			
	4-19	6-7	7-15	8-26	10-1
Ind. 62-235	4.3	5.7	5.3	5.7	5.7
Ind. 62-237	3.6	5.3	5.7	5.3	5.7
Ind. 48-55	5.3	5.0	5.7	4.3	5.7
Ind. 62-247	5.0	5.3	5.7	6.3	6.7
Ind. 62-267	4.3	3.7	4.3	4.3	3.3
Iowa 918-2	3.3	4.7	4.0	4.7	6.0
Iowa 918-3	4.7	5.7	5.3	5.7	5.7
Iowa 46-1	5.0	4.7	4.0	4.0	4.7
Iowa 1317	4.7	4.3	5.0	4.3	4.7
Iowa 1516	6.0	6.0	6.0	7.0	7.0
Kans. 2313	4.7	4.3	3.7	4.3	3.7
Kans 2314	4.3	4.7	4.0	4.7	3.7
Kans. 2315	4.7	4.7	4.3	5.7	6.0
Kans. 2316	4.0	3.3	3.7	3.7	4.0
Kans. 2311	5.7	4.7	3.7	3.7	3.3
Minn. 247	4.7	4.7	4.7	5.3	5.7
Minn. 559	4.0	4.7	5.0	4.3	6.0
Minn. 589	3.0	3.7	4.3	3.7	4.3
Minn. 1166	5.0	6.0	5.7	6.0	6.3
Minn. 1221	5.3	5.7	5.3	5.7	6.7
Nebr. 661	5.7	5.3	5.7	5.7	6.7
Nebr. 662	4.7	6.0	5.3	6.0	5.7
Nebr. 663	5.0	6.0	5.7	4.7	5.3
Nebr. 664	3.0	5.3	6.0	5.3	5.3
Nebr. 665	3.7	4.0	3.3	3.7	4.7
S.D. 1108	6.0	6.0	6.0	6.3	7.0
S.D. H2-8	4.7	4.7	4.0	4.3	5.7
S.D. H2-7	5.7	5.3	5.3	5.7	5.7
S.D. CK25-1	5.0	5.7	6.0	6.0	6.3
S.D. CK27-1	5.7	5.7	4.7	5.3	5.7
Atlantic	3.7	4.3	4.0	3.7	5.0
Buffalo	3.0	3.3	3.3	3.7	3.3
Dawson	3.3	4.7	5.3	5.7	6.7
Narragansett	5.0	5.3	5.3	6.0	5.7
Ranger	3.7	4.0	4.3	4.3	5.3
Vernal	4.3	5.7	5.3	5.3	7.0
L.S.D. at 0.05	0.8	0.7	0.7	0.8	0.8
L.S.D. at 0.01	1.1	1.0	1.0	1.0	1.1
C.V., %	10.8	9.2	9.1	9.0	9.4

[1] Rated as 1 = rapid to 9 = slow

Table 25b. Means of characters measured in 1969 on the open pollinated progenies and control varieties grown in Kansas.

Maternal clone or variety	Stand 10-1-69	Oven dry forage yield 1969 Cut 1	Cut 2	Cut 3	Cut 4	Total	1968 4 cuts	1968-69 Average
	(%)			(t/a)			(t/a)	
Ind. 62-235	98	3.60	2.42	2.01	1.61	9.64	5.44	7.54
Ind. 62-237	97	3.65	2.56	2.26	1.81	10.28	5.30	7.79
Ind. 48-55	98	3.67	2.54	2.33	1.78	10.32	6.11	8.22
Ind. 62-247	96	3.27	2.21	2.09	1.66	9.23	5.21	7.22
Ind. 62-267	99	3.29	2.48	2.53	1.82	10.12	5.76	7.94
Iowa 918-2	98	3.70	2.67	2.29	1.72	10.38	6.18	8.28
Iowa 918-3	96	3.68	2.48	2.32	1.73	10.21	5.87	8.04
Iowa 46-1	96	3.34	2.55	2.34	1.88	10.11	5.86	7.99
Iowa 1317	100	3.05	2.38	2.29	1.70	9.42	6.46	7.94
Iowa 1516	98	3.53	2.16	2.13	1.54	9.36	5.86	7.61
Kans. 2313	97	3.76	2.81	2.49	2.14	11.20	5.94	8.57
Kans. 2314	97	3.83	2.60	2.38	1.93	10.74	6.71	8.73
Kans. 2315	99	3.68	2.52	2.26	1.67	10.13	6.48	8.31
Kans. 2316	100	3.91	2.83	2.56	1.80	11.10	6.62	8.86
Kans. 2311	100	3.28	2.26	2.61	1.81	9.96	6.01	7.99
Minn. 247	87	3.31	2.21	2.17	1.65	9.34	4.95	7.15
Minn. 559	100	4.03	2.60	2.43	1.76	10.82	6.50	8.66
Minn. 589	100	3.67	2.60	2.55	1.89	10.71	6.03	8.37
Minn. 1166	99	3.23	2.14	2.24	1.73	9.34	5.49	7.42
Minn. 1221	97	3.56	2.27	2.12	1.59	9.54	5.71	7.63
Nebr. 661	99	2.95	2.53	2.20	1.60	9.28	6.00	7.64
Nebr. 662	98	3.67	2.34	2.22	1.80	10.03	6.53	8.28
Nebr. 663	99	3.73	2.65	2.22	1.82	10.42	6.14	8.28
Nebr. 664	99	3.73	2.54	2.32	1.73	10.32	6.60	8.46
Nebr. 665	100	3.96	2.73	2.35	1.88	10.92	5.59	8.26
S.D. 1108	100	3.29	2.22	2.28	1.75	9.54	5.56	7.55
S.D. H2-8	97	3.02	2.51	2.30	1.69	9.52	5.75	7.64
S.D. H2-7	96	3.01	2.29	2.15	1.52	8.97	5.24	7.11
S.D. CK25-1	86	3.35	1.93	1.80	1.62	8.70	5.50	7.10
S.D. CK27-1	98	3.13	2.27	2.27	1.62	9.29	5.18	7.24
Atlantic	99	3.45	2.73	2.38	1.74	10.30	5.92	8.11
Buffalo	99	3.24	2.51	2.51	1.77	10.03	5.99	8.01
Dawson	98	3.84	2.72	2.49	1.70	10.75	5.80	8.28
Narragansett	100	3.46	2.51	2.09	1.70	9.76	5.82	7.79
Ranger	98	3.34	2.47	2.35	1.75	9.91	5.67	7.79
Vernal	98	3.50	2.45	2.01	1.60	9.56	5.79	7.68
L.S.D. at 0.05						0.43	0.50	
L.S.D. at 0.01						0.57	0.66	
C.V., %						2.64	5.23	

Table 26a. Means of characters measured in 1970 on the open pollinated progenies and control varieties grown in Kansas.

Maternal clone or variety	Recovery in spring and after cutting					Percent stand
	4-28	6-9	7-9	8-15	9-18	11-18-70
Ind. 62-235	5.7	5.3	5.3	5.7	7.0	96
Ind. 62-237	3.3	5.3	5.7	5.3	5.3	95
Ind. 62-239	6.7	6.7	5.7	5.7	5.3	96
Ind. 62-247	4.7	6.3	6.3	6.7	7.0	95
Ind. 62-267	5.3	5.3	5.0	4.3	5.0	96
Iowa 918-2	5.0	5.3	5.3	4.3	5.3	97
Iowa 918-3	5.3	6.3	6.3	6.3	6.7	98
Iowa 46-1	4.7	5.3	4.3	4.7	5.0	95
Iowa 1317	3.3	5.0	4.7	4.0	5.3	98
Iowa 1516	7.3	6.7	7.3	6.7	7.3	93
Kans. 2313	3.7	4.3	3.3	3.0	4.3	97
Kans. 2314	3.3	6.0	5.0	3.7	5.3	97
Kans. 2315	4.3	5.7	4.7	3.7	5.0	98
Kans. 2316	3.0	3.0	3.0	3.0	3.3	99
Kans. 2311	6.3	4.7	6.0	5.0	5.0	97
Minn. 247	5.0	5.3	5.3	4.7	6.3	87
Minn. 559	5.3	6.0	5.7	5.7	6.0	98
Minn. 589	3.0	4.3	3.7	3.0	3.3	100
Minn. 1166	4.3	5.7	6.0	6.7	6.3	99
Minn. 1221	5.3	5.3	6.3	6.0	6.3	94
Nebr. 661	5.3	6.7	6.7	6.3	6.7	97
Nebr. 662	3.7	7.0	6.3	6.0	5.7	95
Nebr. 663	3.3	6.0	5.7	5.7	6.0	99
Nebr. 664	3.3	6.0	4.3	4.3	5.3	98
Nebr. 665	3.7	4.7	4.3	4.0	4.3	99
S.D. 1108	5.0	6.7	5.7	6.7	7.0	97
S.D. H2-8	3.7	5.3	5.7	3.7	5.3	97
S.D. H2-7	5.3	6.0	5.3	5.3	5.3	93
S.D. CK25-1	5.3	5.7	6.3	3.3	5.7	80
S.D. CK27-1	5.0	5.7	5.3	5.3	5.3	98
Atlantic	3.7	4.3	5.3	4.3	5.3	98
Buffalo	3.7	3.7	3.0	3.3	3.0	98
Dawson	3.3	5.3	5.7	5.7	6.7	99
Narragansett	5.3	5.3	5.7	5.7	6.0	98
Ranger	3.7	4.3	4.3	3.7	5.0	99
Vernal	5.3	6.0	4.3	6.3	6.0	94
Mean	4.5	5.4	5.2	4.9	5.5	96
L.S.D. at 0.05	0.8	0.8	0.8	0.8	0.8	--
C.V., %	11.7	9.6	9.7	10.0	8.1	--

Table 26b. Means of characters measured in 1970 on the open pollinated progenies and control varieties grown in Kansas.

Maternal clone or variety	Yield (tons/acre, dry weight)				
	Cut 1	Cut 2	Cut 3	Cut 4	Total
Ind. 62-235	3.03	1.80	2.23	1.85	8.91
Ind. 62-237	3.34	1.76	2.43	2.14	9.67
Ind. 62-239	2.92	1.78	2.29	1.88	8.87
Ind. 62-247	3.02	1.52	2.27	1.89	8.70
Ind 62-267	2.72	1.85	2.44	1.98	8.99
Iowa 918-2	3.27	1.91	2.40	2.03	9.61
Iowa 918-3	3.25	1.63	2.50	2.10	9.48
Iowa 46-1	3.00	1.80	2.27	1.96	9.03
Iowa 1317	2.77	2.03	2.34	1.91	9.05
Iowa 1516	2.78	1.48	2.36	2.20	8.82
Kans. 2313	3.52	2.16	2.77	2.26	10.71
Kans. 2314	3.45	1.73	2.57	2.11	9.86
Kans. 2315	3.22	1.75	2.42	2.05	9.44
Kans. 2316	3.60	2.42	2.62	2.20	10.84
Kans. 2311	3.05	1.73	2.77	2.04	9.59
Minn. 247	2.95	1.70	2.26	1.87	8.78
Minn. 559	3.45	1.81	2.62	2.12	10.00
Minn. 589	3.70	2.11	2.48	2.01	10.30
Minn. 1166	2.99	1.66	2.55	1.84	9.04
Minn. 1221	3.18	1.75	2.28	1.94	9.15
Nebr. 661	3.15	1.83	2.27	1.80	9.05
Nebr. 662	3.40	1.69	2.46	2.00	9.55
Nebr. 663	3.45	1.76	2.43	1.95	9.59
Nebr. 664	3.26	1.73	2.53	2.16	9.68
Nebr. 665	3.17	2.05	2.47	1.99	9.68
S.D. 1108	3.01	1.79	2.38	2.04	9.22
S.D. H2-8	3.16	2.04	2.33	1.93	9.46
S.D. H2-7	2.83	1.45	2.14	1.81	8.23
S.D. CK25-1	2.81	1.70	2.44	1.90	8.85
S.D. CK27-1	3.15	1.69	2.44	2.06	9.34
Atlantic	3.07	2.15	2.48	1.89	9.59
Buffalo	2.93	1.95	2.32	1.87	9.07
Dawson	3.52	1.93	2.38	1.95	9.78
Narragansett	2.94	1.77	2.21	1.76	8.68
Ranger	3.09	1.88	2.24	1.87	9.08
Vernal	2.74	1.77	2.39	1.92	8.82
Mean	3.14	1.82	2.41	1.98	9.35
L.S.D. at 0.05					0.67

Table 27. Means of characters measured in 1969 and 1970 on the open pollinated progenies and control varieties grown in Nebraska.

Maternal clone or variety	Stand 6-6-69 (%)	Spring growth habit[1] 4-27-70 (score)	Recovery rate[2] 7-7-70 (score)	Fall growth habit[1] 10-1-69 (score)	Fall growth habit[1] 10-25-70 (score)	Fall growth habit[1] Mean (score)
Ind. 62-235	96	5	3	6	4	5
Ind. 62-237	97	4	4	5	3	4
Ind. 48-55	86	6	5	5	4	4
Ind. 62-247	95	4	4	6	4	5
Ind. 62-267	84	4	3	5	4	4
Iowa 918-2	95	4	4	5	3	4
Iowa 918-3	98	5	4	5	4	4
Iowa 46-1	93	5	3	5	4	4
Iowa 1317	89	5	4	5	3	4
Iowa 1516	94	6	6	7	5	6
Kans. 2313	76	5	3	4	5	4
Kans. 2314	94	4	3	3	3	3
Kans. 2315	89	4	4	4	4	4
Kans. 2316	89	4	3	4	3	4
Kans. 2311	94	3	3	3	2	2
Minn. 247	88	6	5	7	5	6
Minn. 559	95	4	4	5	4	4
Minn. 589	94	4	4	5	4	4
Minn. 1166	93	5	4	6	6	6
Minn. 1221	79	5	4	6	4	5
Nebr. 661	92	5	4	6	6	6
Nebr. 662	97	3	4	5	3	4
Nebr. 663	92	5	4	5	4	4
Nebr. 664	95	2	4	4	3	4
Nebr. 665	95	4	3	5	3	4
S.D. 1108	94	6	5	6	6	6
S.D. H2-8	92	4	3	5	4	4
S.D. H2-7	95	6	5	6	6	6
S.D. CK25-1	98	6	5	7	4	6
S.D. CK27-1	92	4	4	5	4	4
Atlantic	95	3	2	2	3	2
Buffalo	97	2	2	5	2	4
Dawson	87	4	3	4	4	4
Narragansett	97	4	4	4	5	4
Ranger	95	2	2	3	3	3
Vernal	94	4	4	5	4	4
Mean	92	4	4	5	4	4
$W(0.05)$	N.S.	3	3	3	3	-
C.V., %	12	20	25	19	23	-

[1] 1 = upright, 9 = prostrate

Table 28. Means of characters measured in 1968 on the open pollinated progenies and control varieties grown in South Dakota.

Maternal clone or variety	Stand 8-18-68 (%)	Leaf hopper[1] injury 9-10-68 (score)	Oven dry forage yield 1 cut (t/a)
Ind. 62-235	96	4	.95
Ind. 62-237	95	3	.96
Ind. 48-55	94	3	.97
Ind. 62-247	93	3	.90
Ind. 62-267	91	4	.92
Iowa 918-2	93	3	1.05
Iowa 918-3	95	4	1.21
Iowa 46-1	95	6	1.00
Iowa 1317	92	4	1.13
Iowa 1516	96	3	1.24
Kans. 2313	92	3	.94
Kans. 2314	94	3	1.08
Kans. 2315	94	3	1.00
Kans. 2316	95	3	1.04
Kans. 2311	91	8	1.04
Minn. 247	93	5	1.16
Minn. 559	93	3	.91
Minn. 589	96	3	.97
Minn. 1166	93	7	1.01
Minn. 1221	97	5	1.07
Nebr. 661	93	2	1.00
Nebr. 662	93	3	.96
Nebr. 663	93	3	1.10
Nebr. 664	94	2	1.06
Nebr. 665	81	4	.77
S.D. 1108	94	3	1.10
S.D. H2-8	94	5	1.08
S.D. H2-7	94	4	.98
S.D. CK25-1	94	3	1.09
S.D. CK27-1	92	5	.88
Atlantic	94	5	.92
Buffalo	92	4	.82
Dawson	92	4	.91
Narragansett	95	4	.95
Ranger	91	4	.88
Vernal	94	3	.96
Mean	93	4	1.00
$^{w}(0.05)$	N.S.	2	.22
C.V., %	6	21	14

[1] 1 = little injury, 9 = severe injury

Table 29. Means of characters measured in 1969 on the open pollinated progenies and control varieties grown in South Dakota.

Maternal clone or variety	Stand 5-6-69 (%)	Spring growth[1] habit 5-6-69 (score)	Recovery[2] rate 8-8-69 (score)	Fall growth[1] rate 9-15-69 (score)	Oven dry forage yield 3 cuts (t/a)
Ind. 62-235	98	3	3	3	5.41
Ind. 62-237	97	2	4	3	5.96
Ind. 48-55	98	3	3	4	5.40
Ind. 62-247	99	3	3	5	5.16
Ind. 52-267	93	3	3	2	5.33
Iowa 918-2	99	3	2	3	5.91
Iowa 918-3	98	3	4	5	6.03
Iowa 46-1	99	3	2	4	5.77
Iowa 1317	98	3	3	2	5.76
Iowa 1516	99	2	7	7	6.22
Kans. 2313	98	3	1	3	4.97
Kans. 2314	99	3	1	2	5.40
Kans. 2315	96	3	2	3	5.18
Kans. 2316	99	2	1	2	5.70
Kans. 2311	99	4	2	2	5.21
Minn. 247	97	4	8	6	5.79
Minn. 559	98	2	2	3	5.89
Minn. 589	98	1	2	2	5.35
Minn. 1166	97	3	4	4	5.22
Minn. 1221	98	3	5	5	5.66
Nebr. 661	98	2	2	3	5.56
Nebr. 662	95	2	2	3	5.61
Nebr. 663	98	3	2	3	5.74
Nebr. 664	97	2	2	3	5.77
Nebr. 665	96	2	2	2	5.30
S.D. 1108	98	3	3	5	5.82
S.D. H2-8	99	2	2	3	5.56
S.D. H2-7	96	4	5	7	5.48
S.D. CK25-1	98	3	5	6	6.02
S.D. CK27-1	96	4	4	4	5.42
Atlantic	95	2	2	2	4.90
Buffalo	98	3	3	3	5.18
Dawson	97	2	3	2	5.36
Narragansett	96	3	3	3	5.84
Ranger	96	3	2	3	5.02
Vernal	98	2	4	3	5.88
Mean	97	3	3	3	5.55
$^{w}(0.05)$	5	2	3	3	1.11
C.V. (%)	2	27	33	29	7

[1] 1 = upright, 9 = prostrate

[2] 1 = rapid recovery, 9 = slow recovery

Table 30. Means of characters measured in 1970 on the open pollinated progenies and control varieties grown in South Dakota.

Entry	Spring growth habit 5-19-70	Rate of recovery 8-2-70	Fall growth habit 9-18-70	% stand 5-19-70	Oven dry, tons/A 3 cuts
Ind. 62-235	2	3	4	97	4.04
Ind. 62-237	2	3	3	99	4.19
Ind. 48-55	3	4	4	95	3.97
Ind. 62-247	2	3	4	97	3.91
Ind. 62-267	2	3	2	95	3.99
Ia. 918-2	2	3	3	96	4.03
Ia. 918-3	4	4	4	97	4.18
Ia. 46-1	3	2	3	97	4.17
Ia. 1317	1	2	1	95	4.37
Ia. 1516	6	5	6	97	4.19
Kans. 2313	2	2	3	95	3.86
Kans. 2314	2	1	1	95	3.90
Kans. 2315	2	2	2	96	4.19
Kans. 2316	2	1	4	97	4.38
Kans. 2311	4	3	2	94	3.49
Minn. 247	4	5	5	94	3.78
Minn. 559	2	2	3	97	4.45
Minn. 589	1	1	2	98	4.31
Minn. 1166	2	3	3	97	3.91
Minn. 1221	3	4	4	97	4.18
Nebr. 661	2	2	2	98	4.62
Nebr. 662	2	2	2	95	4.26
Nebr. 663	2	2	3	95	4.65
Nebr. 664	1	2	2	97	4.33
Nebr. 665	2	2	1	95	4.45
S.D. 1108	3	3	4	94	4.14
S.D. H2-8	2	2	2	97	4.51
S.D. H2-7	4	4	3	95	3.91
S.D. CK25-1	3	6	6	97	3.62
S.D. CK27-1	3	3	2	94	4.15
Dawson	1	2	3	94	4.03
Atlantic	2	3	2	95	4.11
Buffalo	1	1	1	96	3.81
Narragansett	2	2	2	97	4.06
Ranger	2	2	2	96	3.94
Vernal	2	2	4	97	4.07
Mean	2	3	3	96	4.11
L.S.D.(0.05)	2	3	3	N.S.	N.S.
C.V., %	28	34	39	2	10

Table 31. Means of seed yield measured in 1968 and 1969 on the open pollinated progenies and control varieties grown in California.

Maternal clone or variety	Seed yield		
	1968	1969	Mean
	(lb/A)	(lb/A)	(lb/A)
Ind. 62-235	458	377	420
Ind. 62-237	412	372	392
Ind. 48-55	512	407	460
Ind. 62-247	487	369	428
Ind. 62-267	635	576	606
Iowa 918-2	502	426	464
Iowa 918-3	449	365	407
Iowa 46-1	341	382	362
Iowa 1317	591	384	488
Iowa 1516	523	342	432
Kans. 2313	434	349	392
Kans. 2314	575	411	493
Kans. 2315	609	416	512
Kans. 2316	742	553	648
Kans. 2311	461	406	434
Minn. 247	399	312	356
Minn. 559	453	419	436
Minn. 589	459	430	444
Minn. 1166	506	482	494
Minn. 1221	542	427	484
Nebr. 661	551	370	460
Nebr. 662	553	498	526
Nebr. 663	575	463	519
Nebr. 664	503	362	432
Nebr. 665	379	395	387
S.D. 1108	450	385	418
S.D. H2-8	471	379	425
S.D. H2-7	423	306	364
S.D. CK25-1	517	351	434
S.D. CK27-1	424	307	366
Ranger	596	458	527
Vernal	477	375	426
Mean	500	402	451
$^{w}(0.05)$	191	203	188
C.V., %	15	19	14

Table 32. Means of seed yield measured in 1969 and 1970 on the open pollinated progenies and control varieties grown in Idaho.

Maternal clone or variety	1969 Stand, %	Seed yield, lbs/A 1969	Seed yield, lbs/A 1970	Seed yield, lbs/A Mean
	(%)			
Ind. 62-235	81	393	296	344
Ind. 62-237	88	419	265	342
Ind. 48-55	89	480	290	385
Ind. 62-247	88	339	252	296
Ind. 62-267	84	385	285	335
Iowa 918-2	95	509	310	410
Iowa 918-3	91	481	275	378
Iowa 46-1	93	416	225	320
Iowa 1317	95	555	312	434
Iowa 1516	88	584	336	460
Kans. 2313	93	563	350	456
Kans. 2314	94	717	352	534
Kans. 2315	86	580	399	490
Kans. 2316	95	627	388	508
Kans. 2311	92	627	296	462
Minn. 247	84	383	254	318
Minn. 559	90	422	351	386
Minn. 589	90	615	287	451
Minn. 1166	90	467	443	455
Minn. 1221	90	627	450	538
Nebr. 661	86	538	365	452
Nebr. 662	97	652	431	542
Nebr. 663	93	649	364	506
Nebr. 664	85	414	346	380
Nebr. 665	89	427	357	392
S.D. 1108	90	566	396	481
S.D. H2-8	90	437	299	368
S.D. H2-7	93	423	277	350
S.D. CK25-1	90	688	381	534
S.D. CK27-1	85	458	281	370
Ranger	95	545	391	468
Vernal	89	665	367	516
Mean	90	520	331	427
$^{w}(0.05)$	15	254	197	181
C.V., %	6	19	22	23

Table 33. Means of seed yield measured in the first and second years of test on the open pollinated progenies and control varieties grown in California and Idaho.

Entry	Seed yield (lb/A)		
	Year 1	Year 2	Mean
Ind. 62-235	387	337	412
Ind. 62-237	270	319	294
Ind. 48-55	300	349	324
Ind. 62-247	605	311	458
Ind. 62-267	368	431	399
Iowa 918-2	265	368	316
Iowa 918-3	486	320	403
Iowa 46-1	413	304	358
Iowa 1317	533	348	460
Iowa 1516	407	339	373
Kans. 2313	452	350	401
Kans. 2314	734	382	558
Kans. 2315	335	408	371
Kans. 2316	524	471	497
Kans. 2311	619	351	485
Minn. 247	687	283	485
Minn. 559	476	385	431
Minn. 589	603	359	481
Minn. 1166	264	463	363
Minn. 1221	524	439	481
Nebr. 661	524	368	446
Nebr. 662	591	465	528
Nebr. 663	700	414	557
Nebr. 664	222	354	288
Nebr. 665	609	376	492
S.D. 1108	533	391	462
S.D. H2-8	574	339	456
S.D. H2-7	327	292	309
S.D. CK25-1	429	366	398
S.D. CK27-1	349	294	322
Ranger	753	425	589
Vernal	718	371	544
Mean	496	368	432
^{w}(0.05)			119
C.V., %			21

Table 34. Summary of step-wise regression for predicting California and Idaho o.p. progeny seed yield means from North Central clonal trait means measured in 1966 and North Central o.p. progeny trait means.

Step number	Variable entered	R	R^2
1	Number coils per pod	.53	.30
2	Fertile o.p. florets (%)	.63	.40
3	Growth habit score	.76	.57 *
4	Wet forage weight per plant (g)	.79	.62
5	Raceme width (mm)	.81	.66
6	Spring growth habit score	.84	.70
7	Forage yield (dry tons per acre)	.85	.73
8	Number o.p. seeds per pod	.86	.74
9	Number florets per raceme	.87	.76
10	Flower color score	.89	.79
11	Number racemes per plant	.90	.82
12	Date initial bloom	.92	.85
13	Stand (%)	.94	.87
14	Rate of recovery score - cut 1	.94	.89
15	Rate of recovery score - cut 3	.95	.90
16	Raceme length (mm)	.96	.92
17	Number stems per plant	.96	.92
18	Rate of recovery score - cut 2	.96	.93
19	Dry forage weight per plant (g)	.97	.94
20	Fall growth habit score	.97	.94
21	Rate of recovery score - cut 4	.97	.94
22	Fertile selfed florets (%)	.97	.94
23	Length longest stem (mm)	.97	.94
24	Seed weight per plant (g)	.97	.94

* No trait below the dashed line when considered significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

Table 35. Summary of step-wise regression for predicting California and Idaho seed yields from clonal trait means measured in the North Central Region in 1967 and o.p. progeny trait means measured in the North Central Region.

Step number	Variable entered	R	R^2
1	Fertile selfed florets (%)	.59	.35
2	Number stems per plant	.70	.49
3	Number o.p. seeds per pod	.80	.64
4	Fertile o.p. florets (%)	.87	.76
------------------------------------*			
5	Flower color score	.89	.78
6	Rate of recovery score - cut 3	.90	.81
7	Date initial bloom	.91	.83
8	Stand (%)	.92	.85
9	Forage yield (Dry tons per acre)	.93	.87
10	Raceme length (mm)	.94	.88
11	Dry forage weight per plant (g)	.95	.91
12	Number coils per pod	.96	.91
13	Length longest stem (mm)	.96	.92
14	Rate of recovery score - cut 4	.96	.92
15	Seed weight per plant (g)	.96	.93
16	Rate of recovery score - cut 2	.96	.93
17	Spring growth habit score	.97	.93
18	Raceme width (mm)	.97	.94
19	Number racemes per plant	.97	.94
20	Number florets per raceme	.97	.94
21	Wet forage weight per plant (g)	.97	.94
22	Rate of recovery score - cut 1	.97	.94
23	Fall growth habit score	.97	.94
24	Growth habit score	.97	.95

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

Table 36. Summary of step-wise regression for predicting average North Central Region progeny forage yields from means of clonal traits measured in the North Central Region in 1966 and progeny traits other than yield.

Step number	Variable entered	R	R^2
1	Spring growth habit score	.66	.43
2	Data initial bloom	.75	.55
3	Flower color score	.82	.67
4	Number stems per plant	.86	.74
5	Rate of recovery score - cut 2	.89	.80
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6	Number coils per pod	.91	.82
7	Fertile o.p. florets (%)	.92	.86
8	Growth habit score	.94	.88
9	Number racemes per plant	.95	.89
10	Rate of recovery score - cut 4	.96	.92
11	Number o.p. seeds per pod	.96	.93
12	Fall growth habit score	.97	.94
13	Stand (%)	.98	.95
14	Number florets per raceme	.98	.96
15	Rate of recovery score - cut 3	.98	.97
16	Wet forage weight per plant (g)	.99	.97
17	Raceme width (mm)	.99	.97
18	Dry forage weight per plant (g)	.99	.97
19	Rate of recovery score - cut 1	.99	.97
20	Seed weight per plant (g)	.99	.98
21	Length longest stem (mm)	.99	.98
22	Fertile selfed florets (%)	.99	.98
23	Raceme length (mm)	.99	.98

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.

Table 37. Summary of step-wise regression for predicting North Central Region progeny forage yields from clonal traits measured in the North Central Region in 1967 and o.p. progeny traits other than forage yield.

Step number	Variable entered	R	R^2
1	Spring growth habit score	.66	.43
2	Date initial bloom	.81	.66
3	Dry forage weight per plant (g)	.85	.73
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4	Rate of recovery score - cut 2	.87	.75
5	Rate of recovery score - cut 4	.88	.79
6	Fertile selfed florets (%)	.90	.81
7	Flower color score	.91	.83
8	Wet forage weight per plant (g)	.92	.84
9	Rate of recovery score - cut 1	.93	.86
10	Number florets per raceme	.94	.88
11	Fertile o.p. florets (%)	.95	.90
12	Number coils per pod	.95	.90
13	Stand (%)	.95	.90
14	Raceme length (mm)	.95	.91
15	Seed weight per plant (g)	.96	.93
16	Number o.p. seeds per pod	.96	.93
17	Fall growth habit score	.97	.94
18	Growth habit score	.97	.94
19	Rate of recovery score - cut 3	.97	.95
20	Number stems per plant	.98	.95
21	Length longest stem (mm)	.98	.95
22	Raceme width (mm)	.98	.95
23	Number racemes per plant	.98	.95

* No trait below the dashed line when considered alone significantly ($P < 0.05$) reduced the residual sum of squares in the regression analysis of variance.