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# Horticultural Evaluation of Eight Foliage Types of Peas Near-isogenic for the Genes *af, tl* and *st*[1]

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*Additional index words.* blonding, vegetable breeding, canopy height, leaf area, leaf mutants, lodging, *Pisum sativum*, yield

***Abstract.*** **Eight foliage types of pea (*Pisum sativum* L.) were tested as near-isogenic lines of 8 cultivers and experimental lines for 2 years at 2 locations. Three blends of those foliage types were also tested at 1 location. Modifications of the pea foliage were determined by the action of the genes *af* (leaflets changed to tendrils), *tl* (tendrils changed to leaflets), and *st* (reduced stipule size). Shelled pea yields of the altered foliage types in pure stands were similar to normal except for the *afaf TITl stst* and *afaf tltl stst* types, which had reduced yields. The *afaf TITl StSt* and *afaf TITl stst* types had superior standing ability, and had less blonding of shelled peas. Yield was positively correlated with leaf area and harvest index. Blonding of shelled peas was positively correlated with leaf area. One of 2 foliage types with the most favorable performance for the 23 horticultural characteristics measured had many small leaflets (*afaf tltl StSt*), while the other had tendrils instead of leaflets (*afaf TITl StSt*). The all-tendril foliage type (*afaf TITl StSt*), either in pure stand or in a blend with another type, appears to have the most potential for replacing the normal foliage type.**

The normal pea leaf may be altered considerably by the genes *af* (*afila*), *tl* (*acacia*), and *st* (*reduced stipule*). The *af* gene replaces the leaflets with tendrils (6, 14), *tl* replaces the tendrils with leaflets (15, 26), and *st* reduces the large stipules to small, strap-shaped ones (17). The interaction of *af* with *tl* (*afaf tltl* genotype, minute-leaflet phenotype) produces a plant with highly branched petioles and many small leaflets (6). In all combinations, these 3 genes produce $2^3$, or 8, foliage types—normal (*AfAf TITl StSt*), *af* (*afaf TITl StSt*), *tl* (*AfAf tltl StSt*), *st* (*AfAf TITl stst*), *aftl* (*afaf tltl StSt*), *afst* (*afaf TITl stst*), *sttl* (*AfAf tltl stst*), and *aftlst* (*afaf tltl stst*) (Fig. 1). For brevity, the foliage types will be designated by indicating only the gene(s) in the homozygous recessive condition.

The *af* and *afst* foliage types, which have tendrils in place of leaflets, have less lodging than, and may yield as many peas as, the normal foliage type (4). In microplots, dry seed yield (19) and total green pod yield from 3 pickings (7) of the *af* foliage type were as high as from the normal-type. However, dry seed yield of *afst* was much lower (19), as it yielded 53 to 74% of the normal foliage type for a number of background genotypes (21). Foliage types such as *tl* have not been acceptable due to their lack of tendrils (20), which are needed for support, although *tl* was the highest yielding of 7 mutant foliage types tested in spaced plantings along trellises by Gritton (8). These 7 foliage types were the same ones tested in this study.

Non-isogenic lines of mutant and normal foliage types have been compared in several investigations (4, 8, 19, 21). In these cases, it is difficult to separate the effect of the foliage type from the effect of the background genotype. Field studies using near-isogenic lines have measured yield as either dry seed yield (13), or

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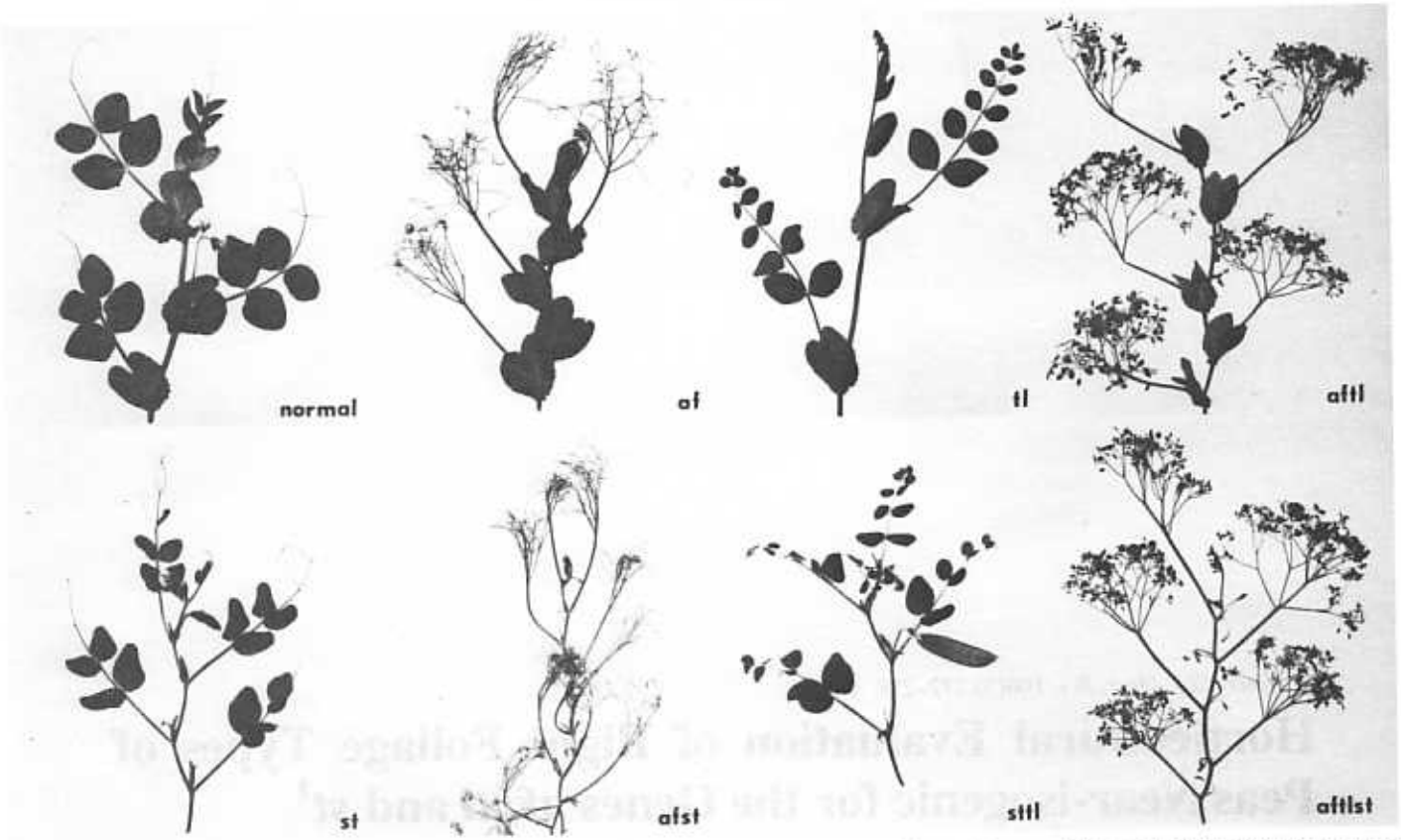


Fig. 1. Foliage types used in this study. Normal has the genotype *AfAf TlTl StSt*. The homozygous recessive gene(s) responsible for each mutant foliage type is (are) shown to the right of each type.

weight of hand-picked pods (7).

Three problems often encountered in the production of processing peas—lodging, blonding, and excess foliage—may be reduced by using different foliage types. Wind and rain, combined with increasing pod weight, usually results in lodging by harvest time. This slows harvesting machinery and may reduce the yield and quality of shelled peas (4). Tendrils support the plants and reduce lodging; reduced lodging may result in greater yield (11).

A uniformly green color of shelled peas is desirable. Shading of the plant, especially the pods, reduces the green color of shelled peas (10, 22, 23). Blond peas have less chlorophyll (1), less dry matter, and a lower boron content than green peas (22). Frequency of irrigation, seed source, seeding rate, location, and rate of fertilization with either macronutrients or micronutrients do not affect blonding (5), but light penetration into the canopy does (9). The modified foliage of some of these mutant foliage types, such as the afila (*af* and *afst*) or minute-leaflet (*aftl*) types may increase the light penetration of the canopy and result in decreased blonding.

Harvest efficiency is very important because processing peas have optimal quality only for several hours. Since excess foliage slows the harvest operation (4), foliage types that have less foliage may have higher harvest efficiency.

Occasionally, blends of genotypes are superior to pure stands. For example, soybean blends have outyielded the best component grown in a pure stand (2, 16, 18). Because of the diverse foliage types available in *Pisum*, pea blends may be superior to pure lines.

Considering the advantages mentioned above for different pea foliage types, our objective in this study was to compare the performance of 7 foliage types with the normal one for yield, lodging, and other horticultural and quality characteristics to test whether any were superior to the normal type.

## Materials and Methods

*Genetic lines*. The genes *af*, *tl*, and *st* were incorporated singly and in all combinations into cultivars 'A45', 'Alsweet', 'Sprite', 'New Season', 'New Line Early Perfection' (NLEP), and 'Dark Skin Perfection' (DSP). Near-isogenic lines of the 8 foliage types were produced using at least 6 backcrosses. 'A45', 'Alsweet', 'New Season', and 'NLEP' are canning types; 'Sprite' and 'DSP' are freezing types. 'A45', 'Alsweet', and 'Sprite' are early-maturing; 'New Season' and 'NLEP' are intermediate; and 'DSP' is a late-maturing cultivar. Some foliage types in some cultivars were not available and were treated as missing data in the analyses.

In addition to the 6 sets of lines, 2 sets were supplied by G. A. Marx, New York Agricultural Experiment Station, Geneva. These were "Line-1" (a freezing type) and "Line-2" (a canning type), with the 8 near-isogenic lines in each background developed by backcrossing.

Three blends were produced by mixing equal weights of seed of 2 foliage types: *af* with *st* (*af* + *st*), *af* with *sttl* (*af* + *sttl*), and *tl* with *st* (*tl* + *st*). There were no significant differences between foliage types for seed weight except for the 'Sprite' *tl* and *st* foliage types (13). It is possible that for the 'Sprite' *tl* + *st* blend the seeds were planted in a ratio of 1:1.07 (*tl*:*st*) instead of the 1:1 ratio used with the other 17 blends.

*Locations and plots*. Trials were conducted during the summers of 1977 and 1978 at 2 locations in Wisconsin—the Arlington Experimental Farm on Plano silt loam soil (typic Arguidolls) and

the Hancock Experimental Farm on Plainfield loamy sand (typic Udipsamments). Plots were 1.2 × 6.1 m, with 6 rows 17 cm apart in each. Adjacent plots were separated by 0.9 m of soil kept free of weeds. The center 5.5-m section of the 2 center rows of each plot was harvested at processing stage (about 100 tenderometer) leaving 0.3 m at each end and 2 rows on each side for border. Borders were harvested at the dry seed stage for measurement of dry seed yield. Weeds were controlled by preplant incorporated trifluralin (α−α−α−trifluoro–2,6–dinitro–N,N–dipropyl–p–toluidine) supplemented by hand weeding.

A population of 800,000 to 900,000 plants/ha was established in 1977. Planting density was increased to 1.0 to 1.5 million plants/ha in 1978 to provide a fuller canopy. Plots were planted April 20–27 at Arlington and April 30 at Hancock in 1977. The 1978 planting dates were April 28–May 2 at Arlington and May 6 at Hancock.

*Characteristics studied*. Data were collected for 23 characteristics although not all were measured in all environments. Twelve characteristics were measured on plants from the plot centers: shelled pea yield, tenderometer, corrected yield (shelled pea yield corrected to 100 tenderometer), foliage weight, harvest index (yield/foliage weight), plant population at harvest, canopy height at weekly intervals until harvest, sieve size, blonding score, and days to emergence, bloom and harvest. Blonding was determined by freezing peas from the yield test and scoring for uniformity of color and number of blonds (yellow shelled peas). Blonding was scored independently by 4 observers on a scale of 1 to 5 (1 = uniformly green samples, 5 = non-uniform samples with several blonds). Sieve size was measured by separating the shelled peas into sieve size 1 through 7, weighing each, and calculating the average size on a weight basis (shelled peas that can fall through a 7.1-mm hole are size 1, sizes proceeding in 0.8-mm steps up to 11.9 mm for size 7). Dry seed yield was measured from the border rows of the plot at the dry seed stage.

In addition to the above, 10 characters were measured on 10 plants from the inside border row of each plot (for leaf area measurement only 3 plants/plot were used). These traits were tillering (1= no tillering, 3= 3 or more plants tillered), vine length, number of nodes/plant, number of pods/plant, number of seeds/pod, lowest pod-bearing node, leaflet area, stipule area, petiole + tendril area (combined area of petioles and tendrils), and total leaf area at the lowest pod-bearing node. All measurements were taken at the processing stage. The area of the petioles and tendrils was measured by recording length and diameter of each branch, and calculating its cylindrical surface area. Leaflets and stipules were removed from the petiole and measured separately on an area meter (Hayashi Denko AAM-5). Only the upper surface area of the leaflets and stipules, and one-half of the petiole + tendril area, were recorded to represent the area intercepting direct solar radiation. Due to the difficulty in measuring leaf area, only 5 of the cultivars and lines were measured. The area of the leaf at the lowest pod-bearing node was used to standardize comparisons.

*Experimental design*. The design was a split-plot in a randomized complete block, with cultivars as whole plots and foliage types within a cultivar as subplots. Whole plots were replicated 4 times at Arlington and 3 at Hancock. Foliage type blends were tested at Arlington in the first 3 blocks in 1977, and in all 4 blocks in 1978. Data from each environment were analyzed separately using a least squares procedure for missing subclasses, since one or more foliage types were missing in most of the cultivars.

Simple correlation analysis was performed for all pairs of the following traits: yield, yield corrected to 100 tenderometer, harvest index, blonding score, leaflet area, stipule area, petiole + tendril area, and total leaf area at the lowest pod-bearing node.

Fisher's LSD was used to test treatment means, and where comparisons were made between means having missing observations, the LSD was calculated according to the method of Watson, as given by Cochran and Cox (3).

## Results and Discussion

Except for tenderometer value and days to emergence, all mean squares of the 23 characteristics analyzed indicated significant differences associated with foliage types. The average tenderometer value was 107, and the average number of days to emergence was 13. No further data have been presented for these 2 traits. Error variances were large for most traits measured, necessitating rather large differences for statistical significance.

### Horticultural performance.

*Pure lines*. Foliage types with normal stipules and extra leaflets (*tl* and *aftl*) tended to have the highest yields, although in only one case was the yield significantly higher than that of the normal foliage type (Table 1). The lowest yields occurred in the *afst* and *aftlst* foliage types, while yields of other types averaged near the normal type. The mutant foliage types yielded better with respect to the normal type in a low-yield environment (Arlington in 1978) than in a high-yield one (Hancock in 1977), possibly indicating more stability in the mutant foliage types. Harvest index values paralleled those for yield.

Canopy height at harvest is an indication of the amount of lodging. The *af*, *afst*, and *aftlst* foliage types had the least lodging at harvest (Table 1). The *st* and *aftl* foliage types lodged as much as the normal type, while both *tl* and *sttl* lodged more. Canopy heights were consistent over years and locations, with *af* and *afst* (afila types) having the best performance over all environments. Blonding decreased in proportion to lodging resistance. Consequently, foliage types with the highest canopies had the most uniformly green shelled peas.

Dry seed yield of the *afst* and *aftlst* foliage types was significantly less than that of the normal type in 1978 (Table 2). The *st* and *sttl* foliage types also yielded less than the normal type at Arlington in 1978. There were few significant differences in plot weight among foliage types, so differences in harvest index were due primarily to differences in yield. Plant population was the same for all foliage types except *af*, *aftl*, and *afst* at Arlington in 1978, which averaged more plants than the normal type. That may have occurred because of smaller seed size (13) which would have resulted in a higher planting rate. The *afst* and *aftlst* types bloomed slightly later than the other foliage types and reached the harvest stage 1 to 4 days later. They were less determinate in their growth habit and their sieve size tended to be slightly smaller than the normal type.

The foliage types *tl* and *aftl* had high dry seed yield, though not significantly higher than that of the normal type, a result similar to that obtained by Gritton (8). The *aftl* foliage type had good horticultural characteristics and less blonding than the normal type. However, as others have found (20), the *tl* type was inferior to the normal type in both standing ability and blonding score, so is considered unacceptable for commerical pea production.

Three foliage types—*af*, *afst*, and *aftlst*—had excellent resistance to both lodging and blonding. However, *af* was the only one with yield and maturity comparable to the normal type. Both *afst* and *aftlst* had low yield and an indeterminate, later-maturing growth habit. Indeterminate growth habit for these 2 foliage types was also observed by Kuepper (13). Despite its unfavorable yield and maturity, an *afst* type may be useful in situations where excel-

Table 1. Mean performance of 8 foliage types (over 8 genetic backgrounds) in pure stands and in 3 blends for 4 major characteristics.[z]

| Character-istic | Year | Location | Normal | Relative performance (% of normal) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pure stand | | | | | | | Blend | | |
| | | | | *af* | *tl* | *st* | *aftl* | *afst* | *sttl* | *aftlst* | *af* + *st* | *af* + *sttl* | *tl* + *st* |
| | | | *(kg/ha)* | | | | | | | | | | |
| Corrected Yield[y] | 1977 | Arlington | 3,669 | 98 | 118 | 86 | 109 | 62 | 93 | 68 | 101 | 121 | 102 |
| | | Hancock | 3,923 | 78 | 107 | 88 | 104* | 74* | 90 | 49* | - | - | - |
| | 1978 | Arlington | 2,414 | 128 | 107 | 109 | 132 | 79 | 97 | 104 | 137 | 109 | 96 |
| | | Hancock | 3,594 | 97 | 99 | 112 | 99 | 56* | 98 | 69* | - | - | - |
| | | | (%) | | | | | | | | | | |
| Harvest index[x] | 1977 | Arlington | 14.5 | 115 | 124 | 95 | 129 | 56 | 100 | 60 | 118 | 139 | 115 |
| | | Hancock | 18.0 | 130 | 116 | 84 | 108 | 60* | 86 | 50* | - | - | - |
| | 1978 | Arlington | 15.9 | 118 | 121 | 136 | 132 | 105 | 122 | 128 | 102 | 104 | 119 |
| | | Hancock | 12.7 | 99 | 106 | 116 | 103 | 75 | 120 | 88 | - | - | - |
| | | | (cm) | | | | | | | | | | |
| Canopy height[w] | 1977 | Arlington | 32.1 | 112* | 93 | 106 | 107 | 147* | 94 | 123* | 108* | 104* | 103 |
| | | Hancock | 37.1 | 124* | 85* | 106 | 96 | 149* | 97 | 118* | - | - | - |
| | 1978 | Arlington | 28.4 | 121* | 95 | 102 | 100 | 133* | 93 | 112 | 119* | 110 | 101 |
| | | Hancock | 36.9 | 119* | 89* | 100 | 95 | 113* | 83* | 109 | - | - | - |
| | | | (score) | | | | | | | | | | |
| Blonding[v] | 1977 | Arlington | 3.1 | 62* | 94 | 93 | 88 | 59* | 117 | 73* | 64* | 66* | 113 |
| | | Hancock | 2.4 | 76* | 97 | 98 | 84 | 48* | 96 | 76* | - | - | - |
| | 1978 | Arlington | 2.1 | 75* | 117* | 84* | 91 | 59* | 84* | 83* | 70* | 80* | 105* |
| | | Hancock | 2.3 | 67* | 120* | 86 | 77 | 59* | 104 | 67* | - | - | - |

[z]Refer to text for explanation of foliage types and gene symbols.
[y]Yield corrected to 100 tenderometer.
[x]Shelled pea weight of plot as percent of plot weight.
[w]Average height of the canopy at harvest.
[v]A score for shelled pea color where 1 = all green, 5 = many yellow.
*Significantly different from the normal foliage type at the 5% level (based on actual means, not on data as percent of normal type).

Table 2. Mean performance of 8 foliage types (over 8 genetic backgrounds) in pure stands and in 3 blends for 5 minor characteristics.[z]

| Character-istic | Year | Location | Normal | Relative performance (% of normal) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pure stand | | | | | | | Blend | | |
| | | | | *af* | *tl* | *st* | *aftl* | *afst* | *sttl* | *aftlst* | *af* + *st* | *af* + *sttl* | *tl* + *st* |
| | | | *(kg/ha)* | | | | | | | | | | |
| Dry seed Yield | 1977 | Arlington | - | - | - | - | - | - | - | - | - | - | - |
| | | Hancock | - | - | - | - | - | - | - | - | - | - | - |
| | 1978 | Arlington | 4,944 | 93 | 92 | 80* | 98 | 57* | 75* | 82* | | | |
| | | Hancock | 5,096 | 101 | 108 | 91 | 106 | 57* | 106 | 85* | - | - | - |
| | | | *(g/plot)* | | | | | | | | | | |
| Foliage wt | 1977 | Arlington | 4,632 | 96 | 103 | 99 | 102 | 100 | 107 | 106 | 94 | 101 | 101 |
| | | Hancock | 4,862 | 96 | 99 | 102 | 106* | 107* | 109* | 86 | - | - | - |
| | 1978 | Arlington | 3,990 | 123 | 103 | 104 | 115 | 110 | 100 | 117 | 118 | 103 | 97 |
| | | Hancock | 5,642 | 98 | 96 | 102 | 98 | 73* | 91 | 88 | - | - | - |
| | | | *(plants/ha)* | | | | | | | | | | |
| Population | 1977 | Arlington | 924,161 | 102 | 96 | 98 | 99 | 110 | 96 | 98 | 98 | 92 | 95 |
| | | Hancock | 821,029 | 102 | 100 | 100 | 93 | 113 | 100 | 94 | - | - | - |
| | 1978 | Arlington | 1,578,062 | 115* | 98 | 108 | 111* | 124* | 108 | 105 | 110 | 100 | 94 |
| | | Hancock | 1,009,904 | 108 | 100 | 108 | 108 | 120 | 104 | 110 | - | - | - |
| | | | *(days)* | | | | | | | | | | |
| Days to bloom | 1977 | Arlington | 41 | 102 | 100 | 99 | 101 | 110 | 101 | 105 | 100 | 102 | 100 |
| | | Hancock | 43 | 100 | 98 | 100 | 97 | 103 | 99 | 102 | - | - | - |
| | 1978 | Arlington | 46 | 100 | 100 | 100 | 100 | 104* | 100 | 103* | 100 | 101* | 100 |
| | | Hancock | 41 | 100 | 100 | 100 | 101* | 101* | 100 | 104* | - | - | - |
| | | | *(sieve)* | | | | | | | | | | |
| Sieve size[y] | 1977 | Arlington | 4.9 | 97 | 104 | 109* | 99 | 87 | 110* | 93 | 106 | 111 | 107 |
| | | Hancock | 5.8 | 99 | 103 | 99 | 98* | 91* | 101 | 94* | - | - | - |
| | 1978 | Arlington | 5.5 | 99 | 99 | 101 | 98 | 97 | 100 | 96 | 96 | 99 | 100 |
| | | Hancock | 5.4 | 94 | 99 | 101 | 96 | - | 101 | 98 | - | - | - |

[z]Refer to text for explanation of foliage types and gene symbols.
[y]Shelled peas that can fall through a 7.1-mm hole are sieve size 1, sizes proceeding in 0.8 mm steps up to 11.9 mm for sieve size 7.
*Significantly different from the normal foliage type at the 5% level (based on actual means, not on data as percent of normal type).

lent standing ability and an open canopy are high priorities. Those 2 characteristics are especially useful in dry pea production.

The *afst* foliage type was expected to have reduced foliage and an increased harvest index. Two findings support those expectations: they have 23% shorter vines and 76% less leaf area than the normal foliage type. However, plot weight of *afst* was not reduced, and its harvest index was only 74% that of the normal foliage type.

Three of the foliage types—*st*, *sttl*, and the blend *tl* + *st*—had no advantage over the normal type. The *st* foliage type has been used successfully in other breeding programs because of its reduced amount of foliage and higher harvest index (12, 19). In this study the yield of *st* was comparable to the normal type, but it did not differ from the normal type in either harvest index or foliage weight. It did, however, have only 68% the leaf area of the normal foliage type.

*Foliage type blends*. Two of the 3 blends tested—*af* + *st* and *af* + *sttl*—consistently outperformed the normal foliage type. They had the highest yields of all foliage types, and along with *tl*, *aftl*, and the *tl* + *st* blend, had the highest harvest index (Table 1). In addition, these 2 blends had taller canopies and less blonding than the normal type (Table 1). Plot weight, plant population, days to bloom and harvest, and sieve size (Table 2) remained about the same as for the normal type.

**Plant characteristics.**

Data taken from measuring individual plants help explain the agronomic performance of the foliage types (Table 3). Most tillering occurred in the types with reduced stipules—*st*, *afst*, *sttl*, and *aftlst*. Two of the 3 foliage types with the tallest canopies (Table 1), *afst* and *aftlst*, had the shortest vines, while the third, *af*, had long vines. Vines of all types with reduced stipules were significantly shorter than vines of the normal foliage type. The 2 foliage types with the shortest vines also had the highest number of nodes per plant. The first pod was borne on a higher node in the *aftl*, *afst*, *sttl*, and *aftlst* foliage types than in the normal type at Arlington in both years. These characteristics—short vines, many nodes, and many days required to reach bloom—indicate that the *afst* and *aftlst* foliage types were later-maturing and less determinate in growth habit than the normal type. They had the fewest number of pods per plant of any of the types evaluated. However, the number of seeds per pod was not consistently associated with any foliage type.

**Leaf area.**

Because the *af* gene produces plants with the leaflets replaced by tendrils, the *af* and *afst* foliage types have no leaflet area (Table 4). The minute-leaflet foliage types (*aftl* and *aftlst*) had the greatest leaflet areas with 55 and 71% greater than the normal type, respectively. The *tl* and *sttl* foliage types had greater leaflet area

Table 3. Mean performance of 8 foliage types (over 8 genetic backgrounds) in pure stands for 6 plant characteristics.[z]

| Characteristic | Year | Location | Relative performance (% of normal) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Normal | *af* | *tl* | *st* | *aftl* | *afst* | *sttl* | *aftlst* |
| | | | *(score)* | | | | | | | |
| Tillering[y] | 1977 | Arlington | - | - | - | - | - | - | - | - |
| | 1978 | Arlington | 1.2 | 99 | 100 | 121* | 115 | 126* | 110 | 119 |
| | 1978 | Hancock | 1.1 | 106 | 106 | 137* | 101 | 144* | 147* | 115 |
| | | | *(cm)* | | | | | | | |
| Vine length | 1977 | Arlington | 72 | 96 | 92 | 87* | 86 | 74* | 83* | 69* |
| | 1978 | Arlington | 51 | 106* | 98 | 90* | 99 | 83* | 86* | 84* |
| | 1978 | Hancock | 72 | 102 | 97 | 89* | 88 | 70* | 85* | 73* |
| | | | *(No.)* | | | | | | | |
| Nodes/plant | 1977 | Arlington | 18 | 100 | 97 | 103 | 102* | 113* | 104* | 107* |
| | 1978 | Arlington | 16 | 101 | 99 | 98 | 99 | 104 | 99 | 103 |
| | 1978 | Hancock | 18 | 102 | 101 | 101 | 96 | 116* | 98 | 121* |
| | | | *(No.)* | | | | | | | |
| Pods/plant | 1977 | Arlington | 4.8 | 92 | 106 | 74* | 125 | 46* | 71* | 46* |
| | 1978 | Arlington | 2.7 | 106 | 107 | 96 | 107 | 68* | 96 | 77* |
| | 1978 | Hancock | 3.2 | 97 | 108 | 107 | 84 | 83* | 101 | 65* |
| | | | *(No.)* | | | | | | | |
| Seeds/pod | 1977 | Arlington | 4.9 | 95 | 106 | 109 | 113 | 106 | 118 | 184 |
| | 1978 | Arlington | 3.2 | 100 | 104 | 103 | 128* | 103 | 101 | 119 |
| | 1978 | Hancock | 4.4 | 99 | 97 | 101 | 104 | 103 | 93 | 98 |
| | | | *(node)* | | | | | | | |
| Lowest pod-bearing node | 1977 | Arlington | 13 | 104 | 97 | 105 | 106* | 123* | 104* | 116* |
| | 1978 | Arlington | 13 | 105 | 103 | 102 | 117* | 110* | 105* | 111* |
| | 1978 | Hancock | 14 | 97 | 95 | 96 | 97 | 112 | 101 | 107 |

[z]Refer to text for explanation of foliage types and gene symbols.
[y]Scored 1 if no tillering occurred, to 3 if at least 3 plants tillered in a 10-plant sample.
*Significantly different from the normal foliage type at the 5% level (based on actual means, not on data as percent of normal type).

Table 4. Mean leaf area, and 3 components of leaf area, at the lowest pod-bearing node for 8 foliage types (over 5 genetic backgrounds) grown at Arlington in 1977.[z]

| Leaf area component | Normal | Relative performance (% of normal) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *af* | *tl* | *st* | *aftl* | *afst* | *sttl* | *aftlst* |
| | *($cm^2$)* | | | | | | | |
| Leaflet area | 86 | 0* | 130 | 113 | 155* | 0* | 162* | 171* |
| Stipule area | 80 | 95 | 93 | 13* | 85 | 14* | 11* | 8* |
| Petiole + Tendril area[y] | 16 | 213* | 72 | 111 | 305* | 186* | 76 | 346* |
| Total leaf area | 182 | 62* | 108 | 68 | 137* | 24* | 90 | 118* |

[z]Refer to text for explanation of foliage types and gene symbols.
[y]Combined area of petioles and tendrils.
*Significantly different from the normal foliage type at the 5% level (based on actual means, not on data as percent of normal type).

than the normal type, but only in the case of *sttl* was that difference significant.

The 4 foliage types with reduced stipules (*st*, *afst*, *sttl*, and *aftlst*) had stipules 8 to 14% the area of normal stipules. The remaining component of leaf area, petiole + tendril area, was greatest in the minute-leaflet foliage types, which is primarily the result of numerous petiole branches since minute-leaflet types have no tendrils. The extra-tendril foliage types (*af* and *afst*) had approximately twice the petiole + tendril area of the normal type.

Total leaf area (the combined areas of the leaflets, stipules, petioles, and tendrils) accounts for most of the photosynthetic surface of the plant. The minute-leaflet foliage types were the only 2 types with significantly greater leaf area than the normal type. However, the greater leaf area of these 2 foliage types did not always result in higher yields than the normal type. The smallest leaf area occurred in the *afst* foliage type, with only 24% the area of the normal type. It is interesting that the *af* foliage type averaged only 62% the leaf area of the normal type, yet its shelled pea yield was about the same.

**Correlations.**

The simple phenotypic correlations for the 8 variables involving yield, blonding, and leaf area indicate that an increase in leaf area was associated with an increase in yield (Table 5). Blonding was not correlated with yield, or with stipule or petiole + tendril area, but was correlated with leaflet area. This demonstrates the value of the *af* and *afst* foliage types in reducing the amount of blonding. Increasing the area of stipules, petioles, and tendrils may be one way of increasing yield without affecting the blonding score. The correlations do not support the observation that leaflet area increases as stipule area decreases (17, 24).

## Conclusions

There were few significant differences between the normal foliage type and the 7 mutant foliage types for yield and harvest index. The *af* and *afst* types consistently had greater resistance to lodging and blonding than the normal foliage type. Pure stands of *af* and *aftl* performed well, as did the blends involving *af* (*af* + *st* and *af* + *sttl*). Apparently, the extra area in the leaflets of *st* and *sttl* complemented the lodging resistance of the extra tendrils of *af* in those blends. For vining pea production, *af* and blends with *af* have the most potential to replace the normal foliage type.

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Table 5. Simple phenotypic correlations between pairs of 8 variables for yield, quality, and leaf area measured on 8 foliage types (over 5 genetic backgrounds) at Arlington in 1977.

| | Yield | Corrected yield | Harvest index | Blonding score | Total leaf area | Leaflet area | Stipule area |
|---|---|---|---|---|---|---|---|
| Corrected yield[z] | .830** | | | | | | |
| Harvest index[y] | .699** | .418** | | | | | |
| Blonding score[x] | .155 | .206 | -.092 | | | | |
| Total leaf area[w] | .614** | .620** | .223* | .354** | | | |
| Leaflet area | .483** | .452** | .147 | .449** | .877** | | |
| Stipule area | .464** | .562** | .292** | .139 | .583** | .167 | |
| Tendril + petiole area[v] | .331** | .301** | .006 | -.212 | .517** | .214 | .388** |

[z]Yield corrected to 100 tenderometer.
[y]Shelled pea yield from plot/plot weight.
[x]Blonding score was rating for shelled pea color where 1 = all green, 5 = many yellow.
[w]Leaf area was measured on the leaf at the lowest pod-bearing node for 3 plants per plot.
[v]Combined area of the tendrils and petioles.
*,**r value significant at the 5 and 1% level, respectively.

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