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# Identification of Soybean Genotypes in Wide Rows for Use in Narrow-row Culture

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## ABSTRAK

*Tiga puluh warisan dan enam kultivar kacang soya (*Glycine max *(L.) Merr.) telah dinilaikan di dalam jarak barisan luas (76 sm) dan rapat (18 sm), di dua lokasi pada tahun 1982 dan satu pada tahun 1983. Objektif kajian ini ialah untuk menentukan sama ada penilaian di dalam barisan luas boleh digunakan untuk mengenalpasti warisan-warisan yang unggul untuk kultur barisan rapat. Hasil di dalam barisan rapat adalah 27.0% lebih tinggi dari barisan luas di kedua-dua lokasi pada tahun 1982 dan 20.8% lebih tinggi pada tahun 1983. Pada amnya, entri-entri yang berhasil tinggi di dalam barisan luas juga merupakan yang berhasil tinggi di dalam barisan rapat, walaupun ianya tidak semestinya merangkumi semua yang berhasil tinggi di dalam barisan rapat. Satu kultivar dan dua warisan, walau bagaimanapun, adalah kekal menunjukkan respons yang sederhana tinggi kepada penurunan jarak barisan di kedua-dua tahun dan lokasi. Tiada ciri telah dikenalpasti berkait dengan respons tersebut. Pada amnya, pemilihan untuk warisan-warisan yang unggul di dalam nurseri-nurseri barisan luas akan dapat mengenalpasti warisan-warisan yang akan berprestasi tinggi di dalam kultur barisan rapat.*

## ABSTRACT

*Thirty lines and six cultivars of soybeans (*Glycine max *(L.) Merr.) were evaluated in wide-row (76 cm) and narrow-row (18 cm) spacings at two locations in 1982 and one in 1983. The objective of the study was to determine if evaluation of lines in wide rows can be used to identify superior lines for narrow-row culture. Yield in narrow rows was 27.0% higher than wide rows at both locations in 1982 and 20.8% higher in 1983. In general, the high yielding entries in wide rows were also the highest yielding ones in narrow rows, although they did not necessarily include all the highest yielding ones in narrow rows. One cultivar and two lines were, however, consistent in exhibiting a moderate to high response to narrowing of row spacing, over years and locations. No trait was identified as being associated with the response. In general, selection of lines superior in wide row nurseries will identify lines that will perform best in narrow-row culture.*

## INTRODUCTION

Soybean [*Glycine max* (L.) Merr.] yields in the North Central U.S. have been shown to increase by narrowing the row width (Cooper, 1974; Costa *et al.*, 1980; Green *et al.*, 1977; Hartung *et al.*, 1980). More efficient light interception and water-use was associated with narrow-row culture (Hicks *et al.*, 1969; Peters and Johnson, 1960; Shaw and

Weber, 1967; Taylor, 1980). Cultivars were found to differ in the degree of response to narrowing of row widths, depending on the plant morphological and physiological characteristics (Cooper, 1977; Costa *et al.,* 1980; Lehman and Lambert, 1960). Cooper (1977) and Costa *et al.* (1980) found that early maturing cultivars exhibited a greater yield response to narrow row spacing than did late maturing ones. Small leaflet size and low leaflet mass in the late-maturing groups were also associated with high yields in narrow-row plantings (Metz *et al.,* 1984). Weaver and Wilcox (1982), however, reported that the response was not affected by maturity. Short and lodging-resistant lines were also reported to be more responsive to narrow rows (Cooper, 1976); Costa *et al.,* 1980; Green *et al.,* 1977).

The number of branches on soybean plants decreases as the plant spacing decreases (Costa *et al.,* 1980; Lehman and Lambert, 1960; Weber *et al.,* 1966). However, the reduction in the number of branches associated with narrow row plantings does not necessarily lead to a reduction in yield, because greater amounts of each of the yield components were produced by the main stem rather than the branches (Lehman and Lambert, 1960).

Most soybean cultivar development and testing programmes are carried out based on the traditional wide-row (76 cm) culture. Consequently, lines which might do well in the narrow rows may not have been selected in the wide-row nurseries. Possible reliability of breeding and evaluating soybeans in the wide rows for use in the narrow-row culture has not been extensively studied. Identification of key morphological and physiological traits contributing to superior performance in narrow rows would be useful in breeding and selecting genotypes in wide rows for maximum production in narrow rows (Shibles and Weber, 1966). The objectives of this study were (1) to evaluate the performance of experimental lines and cultivars under wide (76 cm) and narrow (18 cm) rows, so as to determine if the same lines were superior in both wide and narrow rows, and (2) to determine if keys traits can be measured in wide rows to predict for superior performance in narrow rows.

## MATERIALS AND METHODS

Thirty experimental lines and six adapted cultivars with diverse genetic background of maturity groups ranging from Group I to III were used in the study. Pedigrees of the entries are shown in Table 1.

The entries were evaluated in Wisconsin, U.S.A., at the University of Wisconsin Research Farm at Arlington in 1982 and 1983, and at the Rock County Farm, Janesville, in 1982. Soil types were Plano silt loam (typic Arguidoll) at both locations. The experiment was conducted in a split-plot arranged in a randomized complete block design with three replications at each environment. Entries were whole plots, while row spacings, wide (76 cm between rows) and narrow (18 cm between rows) were sub-plots. The plots were planted on May 8 and May 12 at Janesville and Arlington, respectively, in 1982, and on May 10 at Arlington, in 1983. The plots were each 3.66 m long and 3.05 m wide. A 4-row wide-row planter was used for planting in the wide-row plots and an 11-row narrow row planter for the narrow-row plots. The wide rows were seeded at the rate of 29.5 seeds per meter-row (387, 513 seeds $ha^{-1}$), while the narrow rows were seeded at the rate of 16.4 seeds per meter-row (592, 034 seeds $ha^{-1}$). Harvesting was done on September 28 and October 16 at Janesville and Arlington, respectively, in 1982, and on October 12 at Arlington in 1983, using a small-plot Hege combine. The harvest area was 4.18 $m^2$ for each of the wide-row plots, and 3.41 $m^2$ for each of the narrow-row plots.

Data were taken on the following characteristics: yield (seed yield at 13.0% moisture content), plant height at maturity, lodging (score of 1 = all plants erect; 5 = all plants lodged), height of lowest pod, number of branches per plant, maturity (number of days from sowing to the date when 95% of pods were brown), days to canopy closure (number of days from planting to the date when plant canopy has occupied all inter-row spaces), days to flowering (number of days from planting to the date when 50% of plants have produced the first flower), number of seeds per pod, 100–seed weight, leaf area per plant (only at Arlington, in 1983), and seed quality (score given considering the amount and degree of wrinkling, defective seed coat, greenishness, and mouldy or rotten seeds, where 1 = very good; 5 = very poor).

Analysis of variance was performed on the data at each environment. Data from the three environments were not combined in the analysis, because tests of homogeneity of error variance

TABLE 1

Pedigrees and pedigree numbers of entries used in the study.

| Entry | Pedigree | Pedigree number |
|---|---|---|
| 1 | Hark X Disoy | 10037 |
| 2 | Corsoy X Disoy | 10064 |
| 3 | Corsoy X Disoy | 10066 |
| 4 | Salut X Blackhawk | 10091 |
| 5 | Salut X Grant | 10126 |
| 6 | Salut X Grant | 10132 |
| 7 | Blackhawk X Grant | 10155 |
| 8 | Salut X Amurskaja | 10175 |
| 9 | Salut X Amurskaja | 10188 |
| 10 | Corsoy X Harosoy | 10209 |
| 11 | Corsoy X Harosoy | 10213 |
| 12 | Hark X Corsoy | 10239 |
| 13 | Hark X Corsoy | 10240 |
| 14 | Hark X Corsoy | 10245 |
| 15 | Hark X Corsoy | 10255 |
| 16 | Hawkeye X Disoy | 10265 |
| 17 | Hawkeye X Disoy | 10266 |
| 18 | Hawkeye X Disoy | 10287 |
| 19 | Blackhawk X Salut | 10313 |
| 20 | Grant X Salut | 10345 |
| 21 | Disoy X Hark | 10372 |
| 22 | Disoy X Hark | 10379 |
| 23 | Harosoy X Corsoy | 10411 |
| 24 | Corsoy X Hawkeye | 10483 |
| 25 | Corsoy X Hawkeye | 10489 |
| 26 | Blackhawk X Hark | 10501 |
| 27 | Blackhawk X Hark | 10523 |
| 28 | Blackhawk X Hark | 10525 |
| 29 | Hark X Harosoy | 10536 |
| 30 | Corsoy X Hawkeye | 10490 |
| Hardin | Cultivar | |
| Corsoy 79 | Cultivar | |
| SRF 200 | Cultivar | |
| Hobbit | Cultivar | |
| Hodgson 78 | Cultivar | |
| Simpson | Cultivar | |

(Cochran and Cox, 1957) conducted showed that the environments were heterogeneous. Simple correlation coefficients were calculated between wide and narrow-row plots for all characteristics. Correlations between yield in narrow-row plots and other characteristics in wide row plots were also computed, to identify key traits measured in wide rows that may be used to predict superior performance in narrow rows. Yield response was defined as the yield of entry in narrow rows minus the yield of the same entry in wide rows, expressed as a percentage of the yield in wide rows.

## RESULTS AND DISCUSSION

The lines and cultivars used in the study differed significantly for yield and all other characteristics measured.

Yields were higher in narrow rows than in wide rows in all three trials (Table 2). Average yields were 2990 kg ha$^{-1}$, 3409 kg ha$^{-1}$ and 2836 kg ha$^{-1}$, respectively, at Arlington in 1982, Janesville in 1982, and Arlington in 1983, for narrow-row plots, and 2372 kg ha$^{-1}$, 2707 kg ha$^{-1}$ and 2359 kg ha$^{-1}$, respectively, in the three environments, for wide row plots. Narrow-row

TABLE 2

Mean values for yield and other plant characteristics of soybean lines and cultivars grown in wide (76 cm) and narrow (18 cm) rows, in three environments.

| Row spacing -cm- | Yield $-kg\ ha^{-1}-$ | Plant height -cm- | Lodging | Height of lowest pod -cm- | Number of branches | Maturity -days- | Canopy closure -days- | Flower-ing -days- | Leaf area[a] $-cm^2-$ | Seeds per pod | 100-seed weight -g- | Seed quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arlington, 1982* | | | | | | | | | | | | |
| 18 | 2990* | 77* | 2.8* | 11.1* | 2.4* | 150.9* | 56* | 72* | – | 2.5 | 14.5 | 2.4 |
| 76 | 2372 | 73 | 2.2 | 8.7 | 3.9 | 152.6 | 98 | 73 | – | 2.5 | 14.5 | 2.4 |
| c.v.(%) | 7.2 | 4.6 | 10.8 | 19.2 | 23.0 | 0.5 | 3.4 | 1.7 | – | 4.3 | 2.5 | 16.5 |
| *Janesville, 1982* | | | | | | | | | | | | |
| 18 | 3409* | 102* | 3.1 | 13.9* | 1.5* | 150.4 | 54* | 66* | – | 2.6 | 15.8* | 2.7 |
| 76 | 2707 | 95 | 3.1 | 11.4 | 3.1 | 150.4 | 86 | 67 | – | 2.6 | 15.3 | 2.6 |
| c.v.(%) | 7.8 | 5.1 | 1.0 | 18.3 | 34.3 | 0.8 | 4.1 | 1.9 | – | 4.5 | 2.9 | 15.9 |
| *Arlington, 1983* | | | | | | | | | | | | |
| 18 | 2836* | 90* | 3.3* | 18.0* | 1.4* | 147.2 | 47* | 76 | 469.6* | 2.5 | 14.7* | 3.0 |
| 76 | 2359 | 85 | 3.0 | 15.2 | 2.4 | 146.9 | 74 | 76 | 451.7 | 2.5 | 14.4 | 3.0 |
| c.v.(%) | 6.7 | 5.4 | 10.3 | 27.8 | 34.5 | 2.5 | 6.9 | 1.5 | 12.8 | 4.8 | 3.5 | 16.4 |

[a] Leaf area measurements were taken only at Arlington in 1983.

*Significant difference between wide and narrow-row plots ($p < 0.05$).

TABLE 3

Ranking of soybean entries based on yield in narrow rows, and their respective yields in wide rows and yield responses, in three environments.

| Arlington, 1983 | | | | Janesville, 1982 | | | | Arlington, 1982 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Entry | Yield | | | Entry | Yield | | | Entry | Yield | | |
| | Narrow–row (kg ha$^{-1}$) | Wide–row (kg ha$^{-1}$) | Response[a] (%) | | Narrow–row (kg ha$^{-1}$) | Wide–row (kg ha$^{-1}$) | Response[a] (%) | | Narrow–row (kg ha$^{-1}$) | Wide–row (kg ha$^{-1}$) | Response[a] (%) |
| Hardin | 3789 | 2828 | 34.0 | Hobbit | 4584 | 3723 | 23.1 | 28 | 3175 | 2470 | 28.5 |
| Simpson | 3487 | 2576 | 35.4 | Hardin | 4311 | 3244 | 32.9 | 24 | 3163 | 2614 | 21.0 |
| Hobbit | 3484 | 2989 | 16.6 | 2 | 4163 | 2984 | 39.5 | 25 | 3144 | 2449 | 28.4 |
| Corsoy 79 | 3477 | 2412 | 44.2 | Simpson | 3998 | 3253 | 22.9 | Hodgson 78 | 3135 | 2249 | 39.4 |
| Hodgson 78 | 3415 | 2765 | 23.5 | Hodgson 78 | 3933 | 2724 | 44.4 | 2 | 3113 | 2601 | 19.7 |
| 3 | 3346 | 2319 | 44.3 | 3 | 3817 | 2775 | 37.5 | Simpson | 3103 | 2564 | 21.0 |
| 24 | 3329 | 2536 | 31.3 | SRF 200 | 3771 | 2915 | 29.4 | 27 | 3102 | 2462 | 26.0 |
| 2 | 3299 | 2587 | 27.5 | 9 | 3722 | 2889 | 28.8 | Hobbit | 3100 | 2969 | 4.4 |
| SRF 200 | 3177 | 2473 | 28.5 | 25 | 3701 | 2958 | 25.1 | 4 | 3072 | 2436 | 26.1 |
| 28 | 3165 | 2456 | 28.9 | 27 | 3631 | 2612 | 39.0 | Hardin | 3070 | 2493 | 23.1 |
| 19 | 3102 | 2370 | 30.9 | 28 | 3601 | 2831 | 27.2 | 15 | 3066 | 2552 | 20.1 |
| 7 | 3076 | 2645 | 16.3 | 11 | 3564 | 2565 | 38.9 | SRF 200 | 3033 | 2385 | 27.2 |
| 23 | 3074 | 2560 | 20.1 | 24 | 3546 | 2982 | 18.9 | 19 | 3010 | 2530 | 19.0 |
| 6 | 3065 | 2266 | 35.3 | Corsoy 79 | 3531 | 2943 | 20.0 | Corsoy 79 | 3000 | 2581 | 16.2 |
| 20 | 3043 | 2302 | 32.2 | 10 | 3527 | 2535 | 39.1 | 13 | 2972 | 2323 | 27.9 |
| 16 | 2993 | 2219 | 34.9 | 19 | 3434 | 2575 | 33.4 | 23 | 2938 | 2464 | 19.2 |
| 17 | 2958 | 2214 | 33.6 | 15 | 3390 | 2797 | 21.2 | 26 | 2932 | 2158 | 35.9 |
| 27 | 2948 | 2202 | 33.9 | 30 | 3379 | 2830 | 19.4 | 3 | 2930 | 2401 | 22.0 |
| 1 | 2925 | 2119 | 38.0 | 29 | 3367 | 2574 | 30.8 | 30 | 2867 | 2256 | 27.1 |
| 14 | 2914 | 2334 | 24.9 | 14 | 3322 | 2991 | 11.1 | 5 | 2841 | 2410 | 17.9 |
| 9 | 2904 | 2265 | 28.2 | 20 | 3299 | 2625 | 25.7 | 9 | 2801 | 2333 | 20.1 |
| 18 | 2886 | 2463 | 17.2 | 13 | 3226 | 2673 | 20.7 | 29 | 2794 | 2392 | 16.8 |
| 8 | 2871 | 2117 | 35.6 | 4 | 3195 | 2500 | 27.8 | 11 | 2721 | 2255 | 20.7 |
| 29 | 2854 | 2322 | 22.9 | 22 | 3186 | 2778 | 14.7 | 17 | 2720 | 2288 | 18.9 |
| 5 | 2853 | 2456 | 16.2 | 5 | 3176 | 2636 | 20.5 | 1 | 2716 | 2256 | 20.4 |
| 11 | 2838 | 2436 | 16.5 | 1 | 3140 | 2602 | 20.7 | 7 | 2712 | 2473 | 9.7 |
| 4 | 2829 | 2408 | 17.5 | 6 | 3128 | 2773 | 12.8 | 18 | 2678 | 2491 | 7.5 |
| 10 | 2802 | 2468 | 13.5 | 12 | 3106 | 2366 | 31.3 | 22 | 2660 | 2087 | 27.5 |
| 15 | 2791 | 2267 | 23.1 | 21 | 3069 | 2106 | 45.7 | 16 | 2638 | 2514 | 4.9 |
| 25 | 2783 | 2412 | 15.4 | 23 | 3003 | 2329 | 28.9 | 6 | 2524 | 2322 | 8.7 |
| 12 | 2774 | 2252 | 23.2 | 8 | 2959 | 2787 | 6.2 | 12 | 2496 | 1996 | 25.1 |
| 22 | 2681 | 2163 | 23.9 | 17 | 2946 | 2618 | 12.5 | 8 | 2465 | 2037 | 21.0 |
| 21 | 2571 | 1946 | 32.1 | 16 | 2941 | 2518 | 16.8 | 21 | 2403 | 1946 | 23.5 |
| 13 | 2528 | 2251 | 12.3 | 7 | 2913 | 2595 | 12.3 | 10 | 2397 | 2250 | 6.5 |
| 30 | 2456 | 2303 | 6.6 | 26 | 2634 | 1976 | 33.3 | 20 | 2313 | 1989 | 16.3 |
| 26 | 2180 | 1718 | 26.9 | 18 | 2501 | 2062 | 21.3 | 14 | 2292 | 1948 | 17.7 |
| Mean | 2990 | 2372 | 27.0 | Mean | 3409 | 2707 | 27.0 | Mean | 2836 | 2359 | 20.8 |
| LSD (0.05) | 379 | 379 | 7.9 | LSD (0.05) | 468 | 468 | 7.5 | LSD (0.05) | 352 | 352 | 6.2 |

[a]Defined as the difference in yield between narrow and wide–row plots, expressed as a percentage of yield in the wide–row plots.

plots produced 27.0% higher yield than wide-row plots at both locations in 1982, and 20.8% higher at Arlington in 1983 (Table 3). Effects of row spacing were significant on plant height, lodging, height of lowest pod, number of branches and days to canopy closure in both years, at Arlington. At Janesville in 1982, the effects were significant for plant height, height of lowest pod, number of branches, days to canopy closure, days to flowering and 100–seed weight (Table 2). Plants in narrow rows were significantly taller, with the lowest pod being higher from the ground, with lesser branches and had earlier canopy closure than those in wide rows, in all trials. Number of seeds per pod and seed quality were not affected by row spacing. Taller plants have been found to be more prone to lodging (Cooper, 1976). In this study, this was true only at Arlington, where lodging was significantly higher in the narrow rows than the wide rows. No difference was found between them at Janesville. At Arlington, plants in narrow rows matured earlier than those in wide rows. No difference was however, exhibited at the other two environments. Plants were earlier-flowering in narrow rows than wide rows at both locations in 1982, but were not affected by row spacing in 1983. Leaf area per plant, which was only measured at Arlington in 1983, was significantly greater in narrow rows than wide rows. One hundred-seed weight was higher in narrow rows than wide rows at Janesville in 1982 and Arlington in 1983, but no difference was exhibited at Arlington in 1982.

Ranking of entries based on yield in narrow rows are shown in Table 3. In general, the high yielding entries in wide rows were also the highest yielding ones in narrow rows. However, the ten highest yielding entries in narrow rows did not include all the ten highest yielding ones in wide rows, and vice versa. This was caused by the difference in the degree of response of entries to row spacing. For example, at Arlington in 1982 (Table 3), Corsoy 79 was ranked fourth in the narrow rows, but was only sixteenth in the wide rows, for yield performance. This shows that the cultivar was very responsive to narrow-row spacing. A similar pattern was shown by Hardin and Simpson in the trial. Considering performance in both row spacings in all trials, Hardin, Hobbit and Simpson were the highest yielding cultivars, while Entries 2, 3, 24 and 27 were the highest yielding lines, comparable to the performance of the cultivars. Entries which showed the most yield response to narrow row spacing were generally, inconsistent over environments (Table 3). However, three entries, namely Hardin and Entries 3 and 27 were consistent in exhibiting a moderate to high yield increase. It is interesting to note that Entries 3 and 27 performed well and ranked quite high in narrow rows, but not in wide rows, generally, in all trials. Entry 3 showed 44.3, 37.5 and 22.0% yield response in narrow over wide at Arlington in 1982, Janesville in 1982 and Arlington in 1983, respectively. These were obviously higher than the overall average response of 27.0, 27.0 and 20.8%, for the three trials, respectively. Entry 27 exhibited a response of 33.9, 39.0 and 26.0% for all the three trials, respectively, which were again, greater than the average over all entries in the respective trials. This clearly demonstrates that neither Entry 3 nor 27 would have been selected for superior yielding ability when grown in narrow rows. Entries showing patterns of response similar to these entries would have been missed out if selection were practised under wide rows only, for yield production in narrow-row culture. However, the superiority of a line in narrow rows could not be predicted as no yield-related plant trait was found unique to these lines.

Simple correlation coefficients between wide and narrow-row plots were highly significant for seed yield and all other plant characteristics measured in all trials (Table 4), indicating that, the average general performance of the entries was similar in wide and narrow rows. Selection of traits for better performance in wide rows could be applied to those entries to be used in narrow-row culture, although some exceptions existed, such as Entries 3 and 27, as discussed. High genotypic correlation between wide and narrow rows was reported by Weaver and Wilcox (1982).

Correlation coefficients between yield in narrow-row plots and plant characteristics measured in wide-row plots are shown in Table 5. As expected, yield was certainly highly significantly correlated between the two row spacings. None of the traits measured in wide rows showed good correlation with yield in narrow rows in all trial. Days to canopy closure and number of seeds per pod measured in wide rows, however, showed negative an positive correlation, respectively, with

TABLE 4

Simple correlation coefficients between wide and narrow-row plots for yield and other soybean plant characteristics, in three environments.

| Characteristics | Correlation coefficients | | |
|---|---|---|---|
| | Arlington 1982 | Janesville 1982 | Arlington 1983 |
| Yield | 0.62** | 0.69** | 0.58** |
| Plant height | 0.84** | 0.81** | 0.84** |
| Lodging | 0.81** | 0.80** | 0.67** |
| Ht. of lowest pod | 0.59** | 0.62** | 0.33** |
| No. of branches | 0.63** | 0.59** | 0.39** |
| Maturity | 0.97** | 0.97** | 0.81** |
| Canopy closure | 0.94** | 0.85** | 0.90** |
| Days to flowering | 0.43** | 0.58** | 0.49** |
| Leaf area | – | – | 0.53** |
| Seeds per pod | 0.79** | 0.74** | 0.77** |
| 100–seed weight | 0.89** | 0.92** | 0.92** |
| Seed quality | 0.57** | 0.63** | 0.56** |

** Significant at 0.01 probability level.

TABLE 5

Simple correlation coefficients between soybean yield in narrow rows and other plant characteristics measured in wide-row plots, in three environments.

| Characteristics measured in wide rows | Correlation coefficient with yield in narrow rows | | |
|---|---|---|---|
| | Arlington 1982 | Janesville 1982 | Arlington 1983 |
| Yield | 0.62** | 0.69** | 0.58** |
| Plant height | 0.11 | 0.03 | – 0.09 |
| Lodging | – 0.13 | – 0.28 | – 0.19 |
| Ht. of lowest pod | 0.26* | 0.22 | 0.24* |
| No. of branches | – 0.23 | – 0.22 | – 0.20 |
| Maturity | – 0.12 | – 0.01 | 0.04 |
| Canopy closure | – 0.35* | – 0.32** | – 0.06 |
| Days to flowering | – 0.14 | 0.12 | – 0.11 |
| Leaf area | – | – | 0.01 |
| Seeds per pod | 0.30** | 0.33** | 0.18 |
| 100–seed weight | – 0.12 | – 0.13 | – 0.23 |
| Seed quality | – 0.15 | 0.02 | – 0.05 |

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

yield in narrow rows only in 1982, but no correlation was exhibited in 1983. No plant characteristic was thus, found to be of absolute predictive value that could be measured in wide rows for superior narrow-row performance.

## CONCLUSION

Selection for superior performance in wide-row nurseries, in general, will identify lines that will perform best in narrow rows. Some lines with superior yielding ability in narrow rows, however, may not be identified from wide row nursery trials. Key traits that could be measured in wide rows and would predict superior performance in narrow rows were not identified. This factor varied with environments. No separate selection programme or breeding nursery is thus, suggested for narrow-row culture, because wide-row nurseries allow better crop management.

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