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Genetic Variability in the Mungbean, *Vigna radiata* (L.) Wilczek[1]

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ABSTRACT

Three hundred and twenty-one strains of mungbeans [*Vigna radiata* (L.) Wilczek] originating from 18 American, Asian, African, and Middle Eastern countries were grown at Columbia, Mo. and evaluated for yield, days to first ripe pod, plant height, length of first branch, pods per plant, number seeds per pod, 1000 seed weight, virus resistance, mildew resistance, percent protein, percent lysine, and percent methionine. A wide range in genetic variability was identified for each character examined. Performance of the 32 (10%) highest-yielding strains is compared with the performance of the total population of 321 strains. Relative to the total population, the high-yielding strains tended to be moderately early, to have moderately large-size plants as measured by height and length of the first branch, to have a large number of seeds per pod and moderately high seed weight, and to be resistant to virus. Protein, lysine, and methionine content varied widely among the high-yielding strains. No single strain excelled in the three yield components — pod number, seeds per pod, and seed weight — or in the three nutritional components — protein, lysine, and methionine.

Additional index words: Green gram, Pulse, Germplasm resources, Yield components, Protein, Lysine, Methionine.

MUNGBEAN (*Vigna radiata* (L.) Wilczek) is a widely grown food grain legume in the Middle East, Pakistan, India, Southeast Asia, Africa, Peru, and other areas. In these areas of the world the mungbean provides an important source of protein for many people for whom animal protein is unavailable, prohibited by cost, or not eaten due to dietary habits. The mungbean is widely regarded to be nonflatulent and easily digested and is a favored pulse for children, invalids, or elderly persons. In the U.S. a small acreage of mungbeans is grown and a large quantity of grain is imported for bean sprouts in Chinese foods.

Genetic improvement of the mungbean has been mostly limited to evaluation and selection within local strains. This has led to a widespread belief that genetic variability in this species is relatively narrow. Nowhere is there a vigorous hybridization program utilizing broadbased germplasm on a scale comparable with that being done in the cereal grains. The first step in any breeding program is to survey the genetic resources available. Piper and Morse (6) described 91 strains of mungbeans representing 16 distinct variety types on the basis of maturity, plant type, height, and seed color. The strains originated from diverse sources but apparently are no longer available. Mat-

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lock and Oswalt (5) have described three commercial varieties developed at the Oklahoma Agricultural Experiment Station. Several reports (1, 2, 3, 4, 7, 8) have been published describing variability in Indian and Philippine varieties.

In this study we assembled the mungbean germplasm resources available in the U.S. and evaluated them for plant and seed characteristics that might be useful in a breeding program. The Oklahoma varieties and a few of the Indian varieties described in their reports are included.

MATERIALS AND METHODS

Three hundred and twenty-one strains of mungbeans were grown at Columbia, Mo. in 1970. The strains were obtained from the USDA, Regional Plant Introduction Station, Experiment, Ga.; the Oklahoma Agricultural Experiment Station; and other sources. The country of origin and the number of strains from each are as follows: India, 162; U.S., 57; Afghanistan, 35; Iran, 23; Pakistan, 13; Thailand, 7; Turkey, 5; China, 4; Guatemala and the Philippines, 3 each; Ivory Coast, 2; and Brazil, Burma, Iraq, Korea, Madagascar, Peru, and Taiwan, 1 each.

Two replications of each entry were planted in a randomized block design, June 8, 1970, on the Department of Agronomy's Bradford Experimental Farm at Columbia, Mo. A plot consisted of a single row, 6 m in length, with 90-cm spacing between rows and with seeds planted with 15-cm spacing within the rows. Nonuniform germination resulted in some variability in actual spacing of plants. Seed was inoculated with a commercial culture inoculant before sowing and nodules were observed on plants examined. An herbicide, chloramben (3-amino-2,5-dichlorobenzoic acid), was applied at time of planting at a rate of 3.37 kg/ha. Plots were harvested in October after a killing frost and were threshed in a raspbar plot thresher. The Bradford Farm is located at approximately 39° N latitude, one that is considerably higher than that where most of the strains had originated. Precipitation for the period June 1 through October 31 totaled 68 cm with 21 and 24 cm being received during the months of August and September, respectively. The excessive precipitation in these 2 months resulted in some rotted seeds, preharvest germination, and shattering. Chemical analyses were made in the Agricultural Experiment Station Laboratories.

RESULTS

The results are presented in Fig. 1 as frequency distribution curves for the total population of 321 strains of mungbeans and of the 32 (10%) highest-yielding strains for grain yield (kg/ha), number of days to first ripe pod, plant height (cm), length of lower lateral branch (cm), number of pods per plant, number of seeds per pod, 100 seed weight (gm), virus score (scale, 0 to 100), mildew score (scale, 0 to 5), seed protein (%), lysine (% of protein), and methionine (% of protein). The data are the averages of the two replications, except for chemical analyses (protein, lysine, and methionine), where seeds from the two replications were mixed and the bulked sample was analyzed.

Grain Yields. Grain yields were harvested from 315 mungbean strains. The yields ranged from 8 to 2,708 kg/ha, with a mean of 777 kg/ha. Nine strains yielded in excess of 2,000 kg/ha, and 99 greater than 1000 kg/ha. Six strains did not produce seed: three did not flower; one flowered too late to produce seeds; and two were so severely damaged by virus disease that they did not produce seed. Of the nine strains exceeding 2,000 kg/ha, seven originated from India and one each from China and the U.S.

Days to First Ripe Pod. Excluding the strains that did not flower, the mungbean strains ranged from 57 to 117 days from planting until date of the first ripe pod with an overall mean of 81 days. The 32 (10%) highest-yielding strains ranged from 67 to 98 days to first ripe pod with an average of 77 days. None of the extremely early or extremely late strains were included in the high-yielding group. The extremely early strains did not produce a plant with sufficient size to set a large yield. The late strains did not have time to set a large yield or pods set did not mature before frost. As an overall average it required 22 days for the pods to mature after flowering.

Height of Plants. Height of the 321 strains ranged from 19 to 104 cm with a mean of 56 cm. The 32 (10%) high-yielding strains ranged from 42 to 90 cm in height with a mean of 67 cm. Height is a component of plant size; to produce a high yield the plant needs sufficient size to produce and nourish a large harvest of pods. There was a tendency for the high-yielding strains to be taller than the average, although some exceptions occurred, notably strains with a strongly prostrate growth habit. Most late-maturing strains also tended to be tall as a result of prolonged vegetative growth. The tall strains that were also late in maturity did not produce large yields because they did not have time to mature a large harvest of pods before frost.

Length of First Lateral Branch. The length of the first (lower) lateral branch ranged from 15 to 99 cm with an overall mean of 48 cm. The branch length of the 32 (10%) highest-yielding strains ranged from 36 to 96 cm, with a mean of 61 cm. Branch length, like height, is a component of plant size. Early strains tended to have short branches and late strains long branches but, as with height, there were exceptions. Some of the more prostrate strains compensated for lack of height with longer branches. In this experiment the rows and plants within rows were spaced widely and the branches were longer than if the plants had been grown at conventional seeding rates.

Pods per Plant. Pods per plant is one of the components of grain yield. Excluding the varieties that did not flower, the number of pods per plant varied from 2 to 238 pods per plant with a mean of 65. The 32 (10%) highest-yielding strains varied from 41 to 134 pods per plant with a mean of 80. None of the 10 strains with largest number of pods per plant were among the 10% high-yielding strains. Strains with a high number of pods per plant usually had fewer seeds per pod, or smaller seeds, or both. The strains with extremely low pod number were mostly either late maturing or virus damaged.

Seeds per Pod. Seeds per pod is a second component of yield. The number of seeds per pod overall ranged from 5 to 15 with an average of 10.7. The 32 (10%) highest-yielding strains ranged from 11 to 15 seeds per pod with a mean of 12.3. The strain highest in yield was also first in number of seeds per pod. These data indicate strongly that a high number of seeds per pod is needed for high grain yield. None of the 10 strains with the highest number of seeds per pod were among the 10 strains with highest number of pods per plant.

1000 Seed Weight. Seed weight is a third component of yield. Overall, the 1000 seed weight ranged from 10 to 85 g with a mean of 30 g. The 32 (10%) highest-yielding strains ranged from 30 to 75 g/per 1000 seeds with a mean of 44 g. The data suggest that moderately heavy seed weight is associated with high

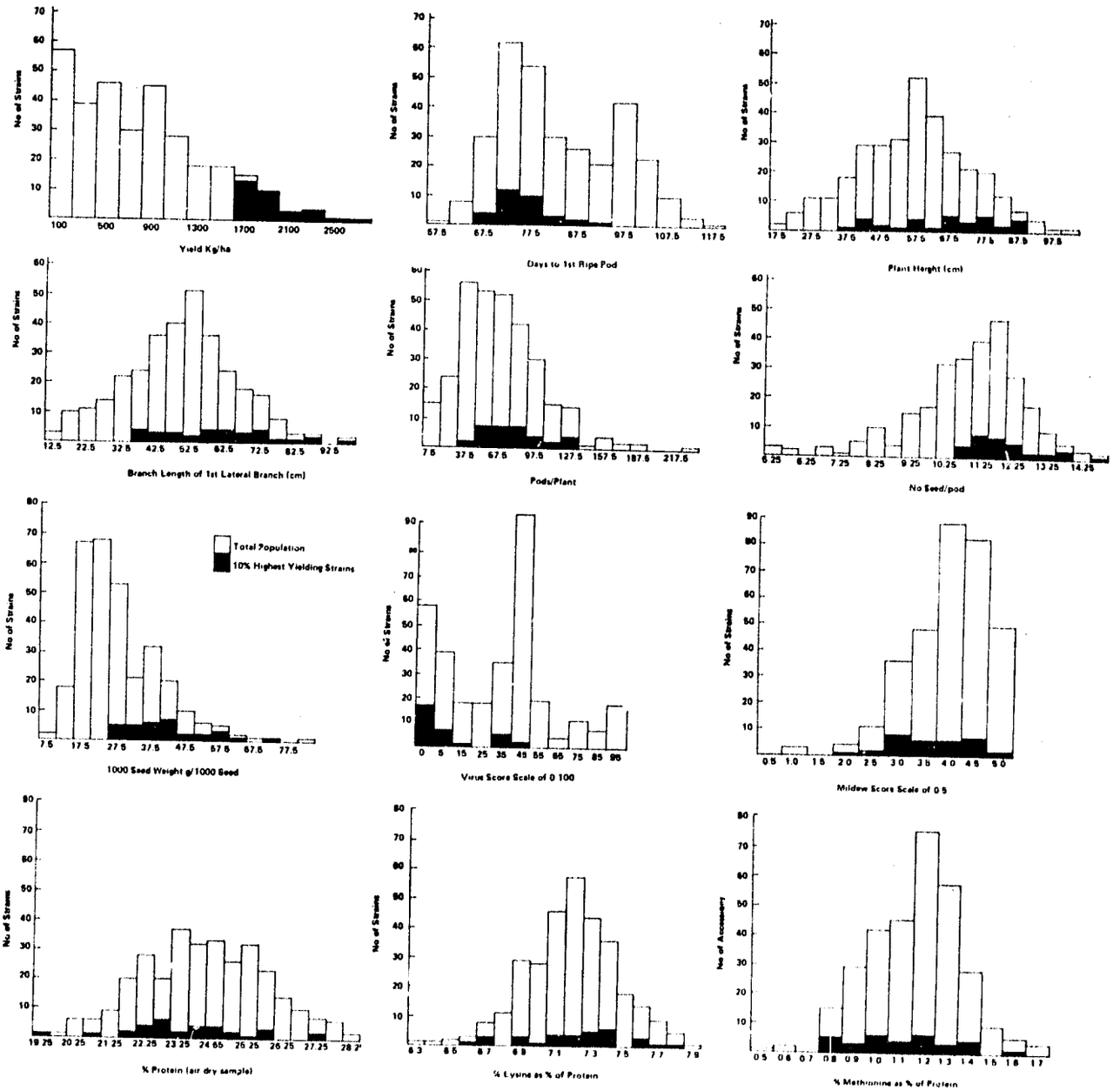

Fig. 1. Distribution of total population of 321 strain of mungbeans and of the 32 (10%) highest-yielding strains for yield (kg/ha), days to first ripe pod, plant height (cm), branch length of first lateral branch (cm), pods per plant, number seeds per pod, 1000 seed weight (g), virus score (scale 0 to 100), mildew score (scale 0 to 5), protein (%, dry weight basis), lysine (as % protein), and methionine (as % of protein).

yield. Four of the 10 strains highest in seed weight were among the 32 high-yielding strains. None of the 10 strains highest in seed weight were among the 10 strains highest in pods per plant, and only one was among the 10 strains highest in seeds per pod. Thus, the three yield components — large number of pods per plant, large number of seeds per pod, and large seed weight — are not favorably combined in any of the strains.

Virus Score. Virus symptoms — mosaic, leaf puckering, stunting, and flower abortion — were observed in varying degrees in a large number of strains. The exact virus, or viruses, were not identified. The bright leaf-yellowing, symptomatic of bean yellow mosaic virus on mungbeans in South Asia, was not observed. Plants within strains varied in the expression of virus symptoms, with both normal and stunted plants observed in the same row. Comparable symptoms and damage were not always observed between replications of the same strain, indicating probable uneven spread of the virus by vectors. Overall damage was assessed and recorded on a scale of 0 to 100. Of the 32 (10%) highest-yielding strains, virus symptoms were not observed in 17 strains and virus scores above 15 were recorded in only 7 strains.

Mildew Score. Powdery mildew (*Erysiphe polygoni* DS) was widespread among the strains. Strains were visually scored on a scale of 0 to 5. Three strains

scored 1 (resistant), four strains scored 2, with 11 additional strains scoring 2.5. The overall mean for mildew score was 3.9, with the 32 (10%) high-yielding strains averaging 3.7. The strains scoring 1 were all very late in flowering. The yield data indicate that mildew was less damaging to grain production than the virus disease in these plots.

Percent Protein. The percent protein recorded for 313 strains ranged from 19.1 to 28.3% (air dry weight basis) with a mean of 24.0%. None of the 10 strains with highest protein was among the 32 (10%) high-yielding strains. The latter ranged from 19.1 to 27.4% protein, with a mean of 23.6%. The high protein strains tended to have small seeds with 1000 seed weight below the population mean.

Lysine (as Percent Protein). The strains analyzed for protein were also analyzed for lysine. They ranged from 6.3 to 7.9% (expressed as percent protein) with a mean of 7.0%. One strain had 7.9%, five strains had 7.8%, and nine additional strains had 7.7% lysine. Two of these 15 strains were among the 32 high-yielding strains. Three strains had a favorable combination of protein and lysine (25.7% protein and 7.9% lysine, 26.9% protein and 7.7% lysine, and 26.4% protein and 7.7% lysine).

Methionine (as Percent Protein). Methionine content (as % protein) was also obtained for 313 strains. The strains ranged from 0.55 to 1.78% methionine, with a mean of 1.2%. One of the eight strains highest in methionine was among the 32 highest-yielding strains. One strain had a favorable combination of protein (26.4%) and methionine (1.52%). Two strains had favorable combinations of lysine and methionine (7.5% lysine and 1.76% methionine, and 7.8% lysine and 1.63% methionine). None had favorable combinations of protein, lysine, and methionine.

DISCUSSION

These studies demonstrate the presence of adequate genetic variability in the mungbean germplasm resources examined to make progress in the breeding phase. New germplasm collections recently received by the USDA's plant introduction division from Iran, India, and other countries will add to these genetic resources. Germplasm collections from additional areas of the world need to be solicited.

Our results show that there is a high yield potential in the mungbean crop. Moderately large plant size, as long as it is not associated with late flowering, appears to be desirable. Due to the wide spacing, large plant size was definitely favored in our experiment, but this might be offset by higher seeding rates. Singh and Malhotra (8) concluded that pod number, seeds per pod, and seed size are important yield-contributing characters and should be given consideration in a breeding program. Potential strains for improving the components of yield — pods per plant, seeds per pod, and seed weight — were identified in this study. What should be the optimum combination of these characters to give maximum yield? Can concomitant improvements be made in the three yield components that will result in higher yield? How will disease reaction affect the expression of the yield components? Here, pods per plant were reduced as a result of flower abortion in strains susceptible to the virus disease complex.

Genetic improvement in protein quantity and quality appears to be possible in the mungbean from the limited observations reported here. The mungbeans, like other food grain legumes, are usually consumed in combination with cereals in the less-developed countries of the world. Of the four amino acids most important in human diets — lysine, methionine, threonine, and tryptophan — the cereals are most deficient in lysine and tryptophan, and the food grain legumes, in methionine. Our results indicate a scope for improving the lysine and methionine as well as total protein in the mungbean.

Early maturing or short-duration varieties of mungbeans are important in many areas where they are grown in multiple cropping systems. We grew the mungbean strains at a high latitude under long summer days. Most mungbeans in the world are grown at lower latitudes with shorter days. In some areas, as in South India, they are grown with short winter days. The performance of the strains studied here may be greatly different in tropical climates with respect to photoperiod responses as well as disease reaction.

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