Tolerance Evaluation Using Different Methods Against Soybean Rust caused by *Phakopsora pachyrhizi*

P. Baiswar[1*], N. Tiameren Ao[2], D.N. Upadhyay[2], S. Chandra[1]

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ABSTRACT

Eight varieties *viz*. NRC 80, DS 2613, MACS 1140, MAUS 417, AMS 1, MACS 1184, JS 335 and MACS 1039 of soybean were screened for tolerance against rust using different methods. Variety NRC 80 was found to be the best according to W*i*P*i* rankings followed by DS 2613 and MACS 1140. Our results show that the use of different measures like P*iu,* W*iu* and W*i*P*i*, both individually and in combination for identification of tolerant varieties, lines are better than the max-min method.

Key words: Soybean, tolerance, max-min method, *WiPi*

INTRODUCTION

Rust caused by *Phakopsora pachyrhizi* is a major problem and hindrance in utilization of full yield potential of soybean in northeast India. This disease was first reported in northeast India from Upper Shillong in Meghalaya. Yield loss estimates indicate 10 % to 90 % loss in India, 10 % to 40 % in Thailand, 10 % to 50 % in the south of China, 23 % to 90 % in Taiwan and 40 % in Japan (Sinclair and Hartman 1999) due to rust. As the resistance sources are very few and almost rare hence other management options like tolerance, fungicidal management etc. are the preferred methods for management of soybean rust. Keeping this in view following experiment on tolerance evaluation was planned for identification of tolerant lines/varieties.

MATERIALS AND METHODS

The experiment was conducted in the experimental field of Plant Pathology, ICAR Research Complex for NEH Region, Umiam, Meghalaya (Latitude 25°30'N, Longitude 91°51'E, Elevation 1000 msl) during 2009 and 2010. Sub-tropical and humid climate prevails at the experimental site. Soil is moderately acidic, sandy loam in texture, rich in organic carbon and available nitrogen, poor in available phosphorus and medium in available potassium (Patiram 2003). Recommended agronomic practices for soybean cultivation were followed.

Eight genotypes *viz*. NRC 80, DS 2613, MACS 1140, MAUS 417, AMS 1, MACS 1184, JS 335 and MACS 1039 were evaluated. Split plot design with three replications was used for the experiment [Main plot: Protected or Sprayed (Fungicide, Bayleton (triadimefon) @ 1ml/L) and nonprotected (Water spray), Sub plot: Different varieties/lines]. Severity ratings (0-9 scale) from the last evaluation before complete defoliation were used for analysis. For yield loss calculations following formulae were used.

Yield loss = Protected or sprayed crop yield - non-protected crop yield

$$\text{Yield loss (\%)} = \frac{\text{Yield loss}}{\text{Protected or sprayed yield}} \times 100$$

A max-min and minimax method (Odulaja and Nokoe 1993) was also used for determination of varieties, which were tolerant (susceptible high

[1]ICAR Research Complex for NEH Region, Umiam, Meghalaya-793103
[2]Department of Plant Pathology, SASRD Campus, Nagaland University, Medziphema, Nagaland
* Corresponding author's E-mail: pbaiswar@yahoo.com

yielding). Percent yield loss using this method was calculated from the yields obtained from protected and non-protected plots. A resistant (entry giving highest yield under nonprotected condition) and susceptible (entry showing maximum percent yield loss) check were identified. Relative yield (*Ry*) was calculated for the i^{th} entry using the formula $Ry = 100Yi/Yr$ where *Yi* is the yield of the i^{th} entry and *Yr* is the yield of the resistant check, both under non-protected condition. Relative yield loss (*Rp*) of the i^{th} entry relative to a susceptible check was calculated as $Rp = 100\ Pi/Ps$ where *Pi* is the percent yield loss of the i^{th} entry and *Ps* is the percent yield loss of the susceptible check. A scatter plot was drawn with *Ry* on *Y* axis and *Rp* on *X* axis. Four quadrants were created with a line on Y axis at 75 and a line on X axis at 25. These four quadrants contained specific entries describing their performance. The superiority measure (P*i*) by Lin and Binns (1988) was used to calculate the protected (P*is*) and nonprotected yields (P*iu*) using the formula:

$$\mathrm{P}i = \sum_{j=1}^{n} \frac{(\mathrm{X}ij - \mathrm{M}j)^2}{2\mathrm{n}}$$

where *n* is the number of seasons, X*ij* is the i^{th} genotype yield in the j^{th} season, and M*j* is the maximum yield response in the j^{th} season. According to this equation the most consistently superior genotype has the lowest P*i* value. The non-protected yields of all 8 varieties/lines were used for calculating P*iu* using the highest non-protected yield each season as the maximum. Likewise P*is* was calculated to determine the change in superiority using the formula:

$$\Delta Pi = pis — piu$$

Ecovalence statistic (W*i*) developed by Wricke (1962) for measuring phenotypic stability was calculated for non-protected yield (W*iu*) and protected yield (W*is*) using the formula:

$$\mathrm{W}i = \sum_{j=1}^{n} (\mathrm{X}ij - \mathrm{X}i. - \mathrm{X}.j + \mathrm{X}..j)^2$$

where *n* is the number of seasons, X*ij* is the i^{th} genotype yield in the j^{th} season, X*i.* is the mean of the i^{th} genotype across *n* seasons, X.*j* is the mean of all genotypes in the j^{th} season, and X.. is the grand mean over n seasons. The lowest W*i* indicates the most stable genotype. The change in the ecovalence statistic was calculated using the formula:

$$\Delta Wi = Wis — Wiu$$

The W*i*P*i* statistic was computed as the distance of the coordinate in the biplot of W*iu* and P*iu* from the origin (Jarvie and Shanahan 2009). W*i*P*i* is the hypotenuse of a right angle triangle with two sides equal to W*iu* and P*iu*. The square of the hypotenuse is equal to the sum of the squares of the two opposite sides, the formula:

$$WiPi = \sqrt{Wiu^2}\ \mathrm{X}\ Piu^2$$

RESULTS AND DISCUSSION

Results revealed that minimum yield loss occurred in case of MAUS 417 (252.7 kg/ha) followed by MACS 1140 (312.5 kg/ha) and 1039 (320 kg/ha) whereas maximum yield loss was recorded in AMS 1 (1485.8 kg/ha) followed by DS 2613 (1045 kg/ha). Results in case of percent yield loss indicated the same pattern as yield loss i.e. maximum yield loss was in case of AMS 1 (54.2%) followed by MACS 1184 (41.1%) and minimum loss in MAUS 417 (16.4 %) followed by MACS 1140 (18.6 %) (Table 1).

Max-min and minimax method (Odulaja and Nokoe 1993), used for determination of varieties which were tolerant (susceptible high yielding), revealed that NRC 80, MACS 1140 and MAUS 417 and DS 2613 were tolerant whereas MACS 1039, JS 335, MACS 1184 were AMS1 were susceptible but low yielding. No variety was in the resistant groups (high yielding and low yielding) (Fig. 1).

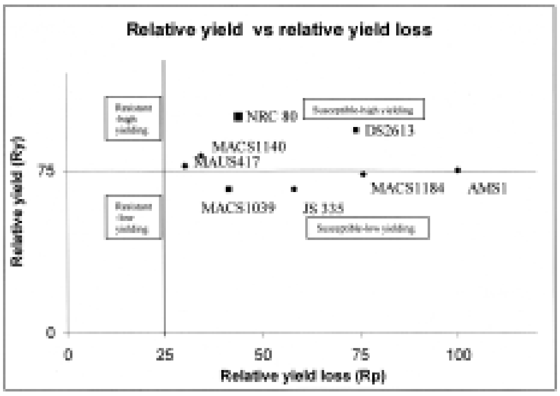

Fig. 1: A max-min and minimax analysis

Table 1: Various yield loss estimates for evaluation for soybean rust tolerance

Varieties	Yield loss (kg/ha)	% Yield loss	P*iu*	P*is*	P*is*-P*iu*	W*iu*	W*is*	W*i*P*i*
MAUS417	252.67	16.39628	0.073069	0.710141	0.637072	0.002509	0.002064	0.073112
MACS1039	320	22.50879	0.165114	0.858436	0.693322	0.010153	0.001039	0.165426
DS2613	1045	40.0639	0.007911	0.008414	0.000503	0.012934	0.00003	0.015161
MACS1184	853.33	41.09149	0.099761	0.215028	0.115267	0.000217	0.000121	0.099761
NRC 80	519.17	23.66122	0.000014	0.144462	0.144448	0.000475	0.00008	0.000476
MACS1140	1485.8	18.60119	0.045762	0.552672	0.50691	0.000184	0.00004	0.045762
AMS1	507.5	54.24399	0.088228	0.00008	-0.08814	0.003134	0.006738	0.088283
JS 335	507.5	31.52174	0.162495	0.62845	0.465955	0.003267	0.000003	0.162528
Standard deviation	433.1	13.2	0.062475	0.336747	0.301577	0.004816	0.002329	0.061297

P*iu* statistic indicated the departure from maximum yield. So, the lowest P*iu* values indicated a better adaptation to the rust. In this case lowest values were for NRC 80 followed by DS 2613 < MACS 1140 < MAUS 417 < AMS 1< MACS 1184 < JS 335 < MACS 1039 (Table 1). Biplot of P*iu* vs P*is* was divided into four quartiles. Quartile C represented lines NRC 80 and DS 2613 which were rust insensitive and superior yielding; quartile D contained lines AMS 1 and MACS 1184 which were rust sensitive but superior yielding. Quartile A had lines MAUS 417 and MACS 1140 which were insensitive to rust but inferior yielding whereas quartile B had JS 335 and MACS 1039 which were rust sensitive and inferior yielding (Fig. 2).

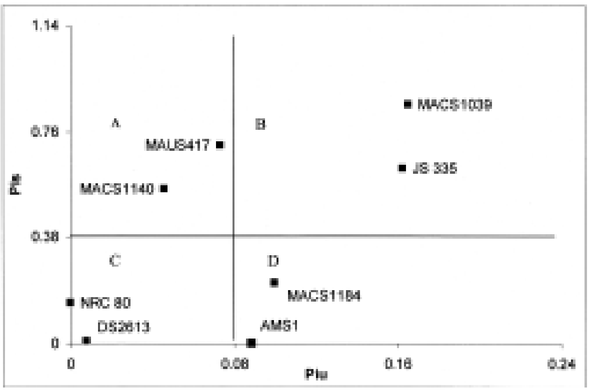

Fig. 2: Biplot of P*iu* vs P*is*

A biplot of W*iu* vs W*is* containing four quartiles was also plotted. Quartile C represented lines, which were consistently stable over the seasons *viz.* NRC 80, MACS 1140 and MACS 1184. Quartile D contained lines, which were stable under sprayed condition but became unstable under rust pressure *viz*. JS 335 and DS 2613. Quartile A contained line, which were unstable under sprayed condition but became stable under rust pressure. No variety or line was present in this category. Quartile B contained lines which are consistently unstable *viz.* AMS 1, MAUS 417 and MACS 1039 (Fig. 3).

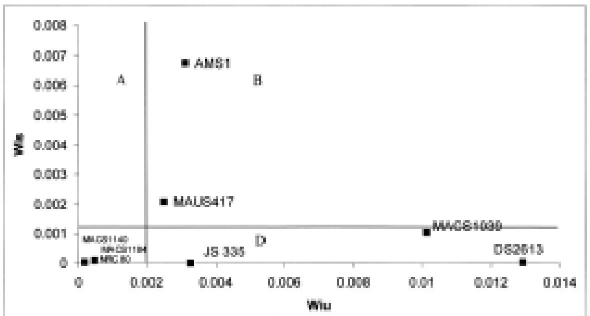

Fig. 3: Biplot of W*iu* vs W*is*

A biplot of P*iu* vs W*iu* was also plotted and divided into four quartiles. Quartile C represented lines, which were superior and with stable yield *viz*. NRC 80, MACS 1140 and MAUS 417. Quartile D contained lines which was inferior but stable yielding *viz*. MACS 1184. Quartile A contained lines, which were superior yielding but unstable *viz*. DS 2613. Quartile B contains lines which were inferior with unstable yield *viz*. AMS 1, MACS 1039 and JS 335 (Fig. 4). Variety NRC 80 was adjudged as the best according to W*i*P*i* rankings followed by DS 2613 and MACS 1140 (Fig. 5).

Our results clearly indicate the superiority of ecovalence statistic and W*i*P*i* (Jarvie and Shanahan 2009) over the max-min method (Odulaja and Nokoe 1993). The discriminatory power or degree of resolution of max-min and minimax method seems to be less in comparison to biplot of P*iu* vs W*iu* and WiPi method. Using WiPi and Piu vs W*iu* it was clear that MACS 1184 was inferior but stable yielding which was identified as susceptible low

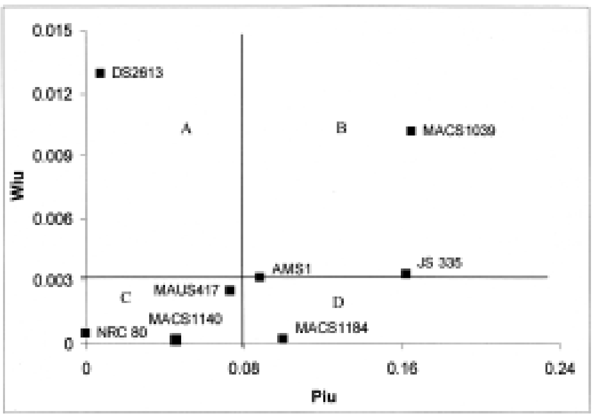

Fig.4: Biplot of P*iu* vs W*iu*

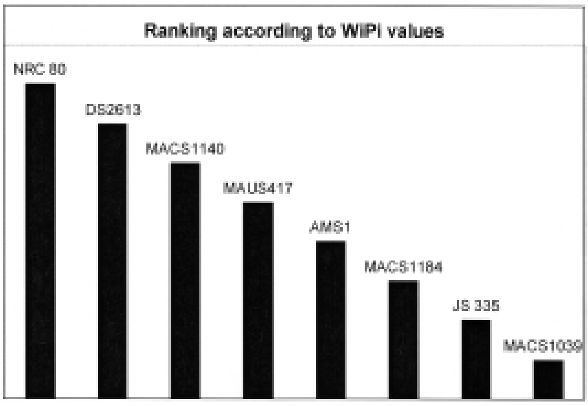

Fig. 5: *WiPi* values of different varieties evaluated for tolerance

yielding in max-min method. Variety DS 2613 was identified as superior but unstable in P*iu* vs W*iu* whereas it was identified as tolerant in max-min method. Actually, during the tolerance evaluation, G x E interaction often compounds the results and makes the interpretation difficult because of seasonal variability over the years hence Flores et al. (1998) suggested evaluation of different indices in different areas for tolerance evaluation. These methods, if used over the years in different agroclimatic regions will definitely help in identifying stable high yielding varieties under severe soybean rust pressure.

CONCLUSION

Out of eight varieties (NRC 80, DS 2613, MACS 1140, MAUS 417, AMS 1, MACS 1184, JS 335 and MACS 1039) screened for tolerance against rust of soybean using different methods, variety NRC 80 was the best according to W*i*P*i* rankings followed by DS 2613 and MACS 1140.

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