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# Effective selection criteria to determine moisture stress tolerance in Indian mustard (*Brassica juncea*)

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## Abstract

Most agronomic traits are highly influenced by environmental conditions, and genetic gains from such traits are primarily conditioned by effective selection methodology. Present investigation, was aimed to find an effective selection criteria for seed yield of Indian mustard [*Brassica juncea* (L.) Czern & Coss], and relationship of selection parameters was also investigated. Moisture stress tolerance index (MSTI) was found effective selection criteria for assessing genotypes for their higher moisture stress tolerance along with higher yield potential. Genotypes PBR-375, RRN702, RH-0735, RH-0555-B, NDRS-2017-1, RGN-282, SKM-815, and Divya 44 showed uniform superiority under both irrigated and moisture stress environments. Contrarily, genotypes PR-2008-13, RGN-281, PR-2007-1, KM-9201, and DRMR-IJ-31 performed better only under irrigated conditions whereas, genotypes HUJM-07-06, SKM B 817, RH-658, DRMR-2010-4, DRMR-868-3, Parasmani-33, KMR-10-1, NPJ-146, RL-2010, RH-0830, RB-650, and RMM 09-3 performed well under rainfed conditions. It is advocated that the genotypes identified in the present study should be further tested at multi-locations, and those found suitable can be used in improvement of breeding programmes for the development of superior genotypes/hybrids in Indian mustard.

***Keywords:*** *Brassica juncea, effective selection criteria, moisture stress tolerance*

## Introduction

Adverse environmental conditions cause more than 50% crop loss worldwide (Bray *et al*., 2000). Among the abiotic stresses, drought is one of the most adverse factors for plant growth and productivity. Indian mustard grown during winter months (*rabi* season) under rainfed conditions in north-western and central India, contributes more than 80% total acreage and production of rapeseed-mustard. In the rainfed and low rainfall regions, its low yield and poor performance, in comparison with the cereals, has limited its adoption by farmers.

Yield stability is a major objective in any breeding programme which could be achieved through effective selection. Research on stress quantification methods and its monitoring in some crop species have received considerable attention, and some selection criteria have been advocated in cereal crops for selecting genotypes on the basis of their performance in stress and non-stress environments (Fischer and Maurer, 1978; Rosielle and Hamblin, 1981). However, in oilseed Brassicas, information regarding suitable selection criteria for assessing genotypes under soil moisture stress and non-stress environments, improving genetic gains for moisture stress tolerance, and their effect on seed yield characters are lacking. The present investigation on Indian mustard, therefore, was undertaken to find suitable, effective selection criteria for seed yield, and also to identify the relationship of effective selection parameters by grouping genotypes on the basis of seed yield and moisture-stress-tolerance.

## Materials and Methods

The present experiment was conducted at experimental area of oilseeds section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during *rabi*, 2010-11.

Thirty-two genotypes of Indian mustard were collected from different AICRP centers and evaluated under irrigated and moisture-stress environments (no irrigation after planting). The experimental material was laid out in randomized block design with three replications. Each genotype was grown in 5 with 5 m long rows but an effective net plot size of 3 rows each with 4.7 m length was used for recording of yield parameters. The crop under irrigated, and moisture-stress conditions was sown on October 15, 2010 and October 17, 2010, respectively. The observations on five comparable randomly selected plants, from each replication were recorded, and the mean values were used for statistical analysis. Recommended package of practices were followed for raising the crop. Parameters including namely days to flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, main shoot length (cm), number of siliquae on main shoot, siliqua density on main shoot, siliqua length (cm), seeds per siliqua, 1000-seed weight (g), oil content (%), seed yield per plant (g), seed yield kg/ha and disease intensity (%) were recorded.

## Statistical analysis

Genotypes were grouped in the following four groups based on their performance in irrigated and moisture-stress environments.

Group A : The genotypes expressing uniform superiority in both stress and non-stress environments

Group B : Genotypes performing favorably only in non-stress environments

Group C : Genotypes yielding relatively high in stress environments

Group D : Genotypes performing poorly in both stress and non-stress environments

The optimal selection criteria should distinguish Group A from the other three groups.

Let $Y_P$ = The potential yield of a given genotype in irrigated environment

$Y_S$ = The actual yields of given genotype in moisture stress environment

$Y_P$-= Mean actual yields in irrigated environment

$Y_S$- = Mean actual yields in moisture stress environment

The following stress tolerance attributes are defined from these four yield measurements.

**Moisture stress intensity (MSI)** $= 1 - \frac{Y_{S^-}}{Y_{P^-}}$

MSI ranges from 0 to 1, and the larger the value of MSI, the more severe is the stress intensity.

**Mean productivity Index (MPI)** =

MP index favours higher yield potential and lower moisture stress tolerance. In most of yield trials, Rosielle and Hambline (1981) identified a positive correlation between MP and $Y_p$, and MP and $Y_s$. Thus, selection based on MP, generally, increases the average performance in both stress and non-stress environments. However, MP fails to distinguish the Group A and Group B genotypes.

**Moisture stress tolerance (TOL)** $= (Y_p - Y_s)$

A large value of TOL represents relatively more sensitivity to moisture stress, thus a smaller value of TOL is favoured. Selection based on TOL favours the genotypes with low yield potential under no moisture stress conditions, and high yield under moisture stress conditions. In most yield trials, the correlations between TOL and $Y_p$ would be positive, and thus, TOL fails to distinguish between Groups C and Group A.

**Moisture stress susceptibility index**

**(MSSI)** $= 1 - \frac{Y_S/Y_P}{DSI}$

Fischer and Maurer (1978) proposed a moisture stress susceptibility index (MSSI), expressed by following relationship i.e., SSI = $[1-(Y_s/Y_p)]$/SI. SI is the stress intensity and is estimated as $[1-(Y_s\text{-}/Y_p\text{-})]$, where, $Y_s$- and $Y_p$- are the mean yields over all genotypes evaluated under stress and non-stress conditions. The smaller the value of MSSI, the greater is the moisture stress tolerance. Under most yield trials, TOL and MSSI are positively correlated. Selection based on MSSI favours genotypes with low yield potential and high yield under moisture stress conditions. Thus, MSSI also fails to distinguish Group A and Group C.

**Geometric mean productivity**

**(GMP)** = $\sqrt{Y_s \times Y_p}$

Mean productivity (MP) is based on the arithmetic means and, therefore, it has an upward bias due to a relatively larger difference between $Y_p$ and $Y_s$, whereas the geometric mean productivity is less sensitive to large extreme values.

Thus, GMP is a better indicator than MP in separating Group A from other groups.

**Moisture stress tolerance index**

**(MSTI)** = $\frac{(Y_p)(Y_s)}{(Y_p)^2}$

MSTI is an estimate based on GMP and, thus, the rank correlation between MSTI and GMP is equal to 1. A higher MSTI value for a genotype suggests the higher level of its moisture tolerance and yield potential. Fernandez (1992) proposed a new MSTI, which can be used to identify genotypes that produce higher yield under both non-stress and stress environments. The moisture stress intensity (MSI) value is also incorporated in the estimation of MSTI. Thus, MSTI is expected to distinguish Group A from Group B and Group C (Fernandez, 1992).

## Results and Discussion

Estimates of moisture stress tolerance attributes from the potential seed yield ($Y_p$) and seed yield under moisture stress environment ($Y_S$) in Indian mustard genotypes are presented in table 1.

Moisture stress intensity is the attribute for judging the moisture stress i.e., how much a genotype can withstand under moisture stress. The value ranges between 0 to 1. Larger the value of moisture stress intensity, more severe is the moisture stress. A perusal of table revealed that the estimate of moisture stress intensity was 0.15, which was considerably important attribute to screen different genotypes for their moisture stress tolerance attributes.

### Mean productivity index (MPI)

Mean productivity index revealed that higher index favours higher yield potential and lower moisture

Table 1. Estimation of stress tolerance attributes from the potential yield and yield in rainfed stress environment in Indian mustard

| Genotypes | Seed yield under Irrigated environment($Y_p$) | Seed yield under moisture stress environment($Y_S$) | MP | TOL | MSSI | GM P | MSTI |
|---|---|---|---|---|---|---|---|
| RGN-281 | 3696 | 2585 | 3141 | 1111 | 2.00 | 3091 | 0.97 |
| PR-2007-1 | 3089 | 2908 | 2999 | 181 | 0.39 | 2997 | 0.92 |
| SKM B 817 | 2774 | 3128 | 2951 | -354 | -0.85 | 2946 | 0.88 |
| PR-2008-13 | 3121 | 3081 | 3101 | 40 | 0.09 | 3101 | 0.98 |
| RGN-282 | 3294 | 3199 | 3247 | 95 | 0.19 | 3246 | 1.07 |
| RRN-702 | 3704 | 3735 | 3720 | -31 | -0.06 | 3720 | 1.41 |
| SKM 815 | 3459 | 2947 | 3203 | 512 | 0.99 | 3193 | 1.04 |
| NPJ-146 | 2719 | 2569 | 2644 | 150 | 0.37 | 2643 | 0.71 |
| Divya 44 | 3680 | 2734 | 3207 | 946 | 1.71 | 3172 | 1.03 |
| RRN-722 | 2474 | 2340 | 2407 | 134 | 0.36 | 2406 | 0.59 |
| NPJ-141 | 2774 | 1828 | 2301 | 946 | 2.27 | 2252 | 0.52 |
| KMR 10-1 | 2537 | 2742 | 2640 | -205 | -0.54 | 2638 | 0.71 |
| NDRS-2003-3 | 2396 | 1868 | 2132 | 528 | 1.47 | 2116 | 0.46 |
| KMR-10-2 | 2490 | 2112 | 2301 | 378 | 1.01 | 2293 | 0.54 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RL-2010 | 3176 | 2151 | 2664 | 1025 | 2.15 | 2614 | 0.70 |
| NDRS-2017-1 | 3719 | 3239 | 3479 | 480 | 0.86 | 3471 | 1.23 |
| DRMRIJ-31 | 2947 | 2994 | 2971 | -47 | -0.11 | 2970 | 0.90 |
| DRMR-868-3 | 3184 | 2561 | 2873 | 623 | 1.30 | 2856 | 0.83 |
| ACN83 | 2664 | 1860 | 2262 | 804 | 2.01 | 2226 | 0.50 |
| PBR 375 | 4106 | 3743 | 3925 | 363 | 0.59 | 3920 | 1.57 |
| DRMR-2010-4 | 3286 | 2545 | 2916 | 741 | 1.50 | 2892 | 0.85 |
| HUJM-07-06 | 3302 | 2648 | 2975 | 654 | 1.32 | 2957 | 0.89 |
| Parasmani-33 | 3089 | 2553 | 2821 | 536 | 1.16 | 2808 | 0.80 |
| NRCDR-2(LR) | 2774 | 2530 | 2652 | 244 | 0.59 | 2649 | 0.72 |
| RMM 09-3 | 2813 | 2183 | 2498 | 630 | 1.49 | 2478 | 0.63 |
| KM-9201 | 3459 | 2624 | 3042 | 835 | 1.61 | 3013 | 0.92 |
| Kranti(NC) | 3255 | 1529 | 2392 | 1726 | 3.54 | 2231 | 0.51 |
| RH0735 | 4145 | 3349 | 3747 | 796 | 1.28 | 3726 | 1.41 |
| RH-58 | 3199 | 2656 | 2928 | 543 | 1.13 | 2915 | 0.87 |
| RB-50(ZC) | 2498 | 2624 | 2561 | -126 | -0.34 | 2560 | 0.67 |
| RH0555 B | 3672 | 3688 | 3680 | -16 | -0.03 | 3680 | 1.38 |
| RH0830 | 2797 | 2459 | 2628 | 338 | 0.81 | 2622 | 0.70 |
| Mean | 3134.125 | 2678.5 | | | | | |
| MSI =.15 | | | | | | | |

$Y_p$ = Yield under irrigated environment (kg/ha); $Y_s$ = Yield under moisture stress environment; MP = Mean productivity; TOL= Moisture stress tolerance; MSSI = Moisture stress susceptibility index; GMP = Geometric mean productivity; MSTI = Moisture stress tolerance index.

stress tolerance. The genotypes, PBR 375 followed by RH0735, RRN-702 and RH 0555B recorded higher mean productivity. Hence, these genotypes retained higher potential seed yield and low moisture stress tolerance. Whereas, the genotype NDRS-2003-3 with us poorest mean productivity index has low yield potential with high moisture stress tolerance level.

**Moisture stress tolerance (TOL)**

Moisture stress tolerance revealed that larger the value of tolerance, relatively more sensitive is a genotype to the moisture stress. Thus, a smaller value of tolerance should be preferred. The genotype, SKM 817 was observed with smallest value and exhibited tolerance to moisture stress. In contrast, Kranti, RGN 281, and RL 2010 with higher values of tolerance indicate that these genotypes were relatively more sensitive to moisture stress.

**Geometric Mean Productivity (GMP)**

Since, mean productivity is based on arithmetic means and therefore, it possesses upward bias due to a relatively larger difference between potential yield under irrigated environment and yield under moisture stress environment.

As geometric mean is less sensitive to large extreme values, the geometric mean productivity (GMP) is a better indicator than mean productivity (MP) in separating genotypes with uniform superiority in both the irrigated and moisture stress environments. The genotypes PBR 375, RH0735, RRN0702, RH0555B, and NDRS-2017-1 were found significantly superior in GMP indicating that these were suitable genotypes for both irrigated and moisture stress environments with higher seed yield potential. The poorest GMP was recorded in genotype NDRS-2003-3, and thus, this genotype should be avoided for rainfed cultivation.

**Moisture Stress Susceptibility Index (MSSI)**

The smaller the value of MSSI the greater is the moisture stress tolerance. Genotypes SKMB 817, KMR-10-1, and RB-50 with significantly low values of MSSI indicate that they all possess significantly higher degree of moisture stress tolerance. Contrarily, Kranti, NPJ-141, and RL2010 with higher MSSI values indicate low level of moisture stress tolerance.

**Moisture Stress tolerance index (MSTI)**

Moisture stress tolerance index was estimated on the basis of GMP. Higher values of MSTI for a genotype reveal its better moisture stress tolerance and yield potential. The genotypes, PBR 375 followed by RH 0735, RRN702 , RH 0555B, NDRS 2017-1, and RGN 282 were identified as promising genotypes for their higher moisture stress tolerance, and higher yield potential. Thus, the MSTI helps in identification of genotypes suitable for irrigated and moisture stress environments. The correlations of Yp with MP, TOL, MSSI and MSTI, and also of Ys with MP, TOL, MSSI and MSTI under both the environments are illustrated by scattered plot diagrams in figure 1 and 2, respectively. The scattered plots indicate that MP and MSTI were better predictors of mean $Y_p$ and $Y_s$ than TOL and MSSI. Overall, MSTI was a better predictor of mean, $Y_s$ and mean, $Y_p$ under moisture stress conditions. Thus, it can be concluded that MSTI is the most appropriate index of yield potential and moisture stress tolerance, to identify genotypes which would perform uniformly better under disease-stress and disease free environments. The observations made in the present study are in confirmation with the earlier report of Fernandez (1992) and Gupta et al., (2002).

Table 2 Grouping of genotypes on the basis of seed yield and moisture stress

| | |
|---|---|
| Group A | PBR-375, RRN702, RH-0735, RH-0555-B, NDRS-2017-1, RGN-282, SKM-815, Divya 44. |
| Group B | PR-2008-13, RGN-281, PR-2007-1, KM-9201, DRMR-IJ-31 |
| Group C | HUJM-07-06, SKM B 817, RH-758, DRMR-2010-4, DRMR-868-3, Parasmani-33, KMR-10-1, NPJ-146, RL-2010, RH-0830, RB-50, RMM 09-3 |
| Group D | RRN-722, KMR-10-2, NPJ-141, Kranti, ACN-83, NDRS-2003-3. |

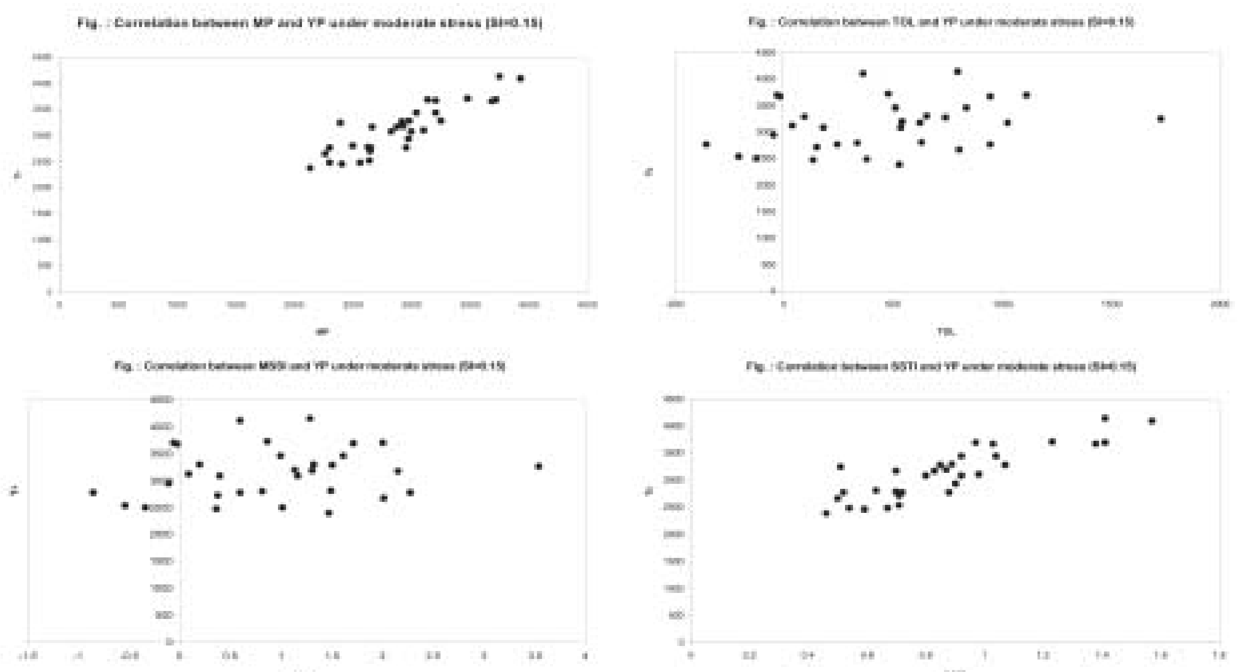

Fig. 1. Correlation between potential yield ($Y_p$) and other stress tolerance attributes under low stress. (SI=0.15)

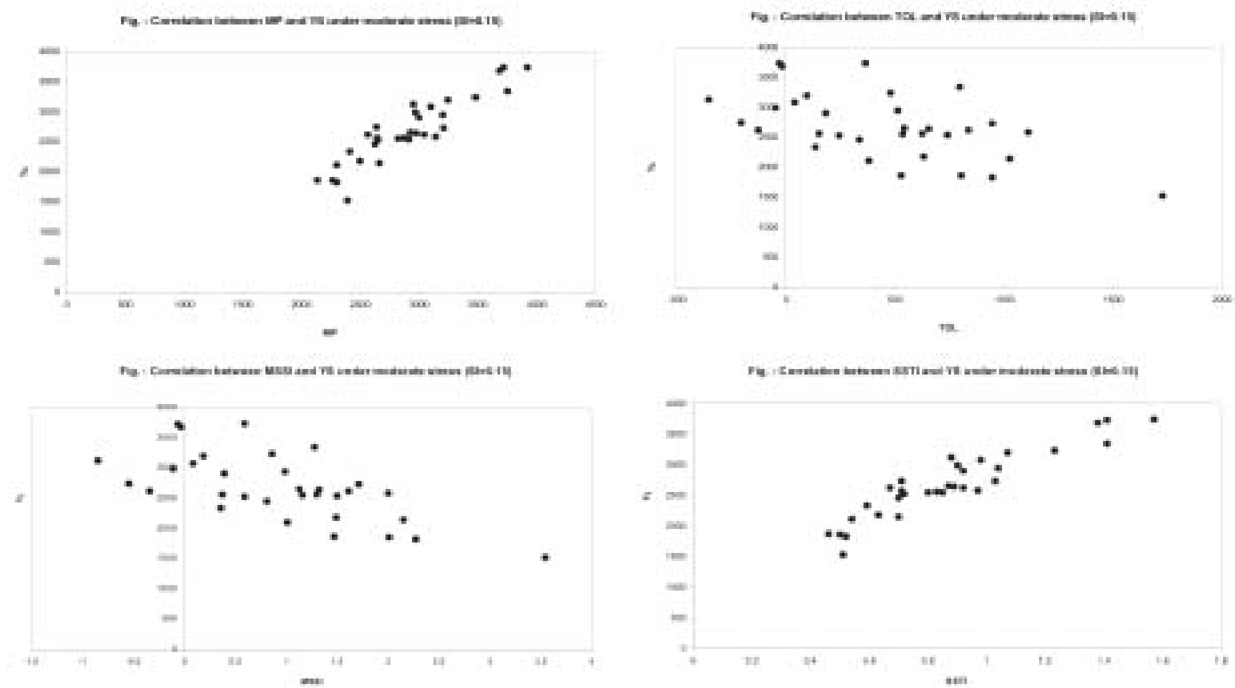

Fig. 2. Correlation between moisture stress yield (Ys) and other stress tolerance attributes under low stress (SI=0.15)

The genotypes, PBR-375, RRN702, RH-0735, RH-0555-B, NDRS-2017-1, RGN-282, SKM-815 and Divya 44 were found superior in both irrigated and moisture stress environments. The genotypes, PR-2008-13, RGN-281, PR-2007-1, KM-9201, and DRMR-IJ-31 performed better in irrigated environment, whereas HUJM-07-06, SKM B 817, RH-58, DRMR-2010-4, DRMR-868-3, PARAS-MANI-33, KMR-10-1, NPJ-146, RL-2010, RH-0830, RB-50 and RMM 09-3 exhibited better performance in rainfed environment. The genotypes RRN-722, KMR-10-2, NPJ-141, KRANTI, ACN-83 and NDRS-2003-3 showed poor performance in both irrigated and rainfed environments.

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