Character association and stress indices for yield components in Saltol introgressed backcross inbred lines of rice (Oryza sativa L.)

S. Banumathy*, K. Veni, R. Anandhababu, P. Arunachalam, M. Raveendran1 and C. Vanniarajan

Department of Plant Breeding and Genetics, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.

Received: 09-10-2017 Accepted: 13-12-2017 DOI: 10.18805/IJARe.A-4926

ABSTRACT

Correlation, path coefficient and stress indices for yield and its components were studied in 32 Saltol introgressed backcross inbred lines (BIL) of rice along with a tolerant parent FL 478, susceptible check IR 29 and two recurrent parents viz., ADT 37 and CR 1009 Sub1 under normal and saline environments during rabi, 2016. Grain yield per plant showed positive significant association with all traits except 100 grain weight under normal environment and it showed positive significant association with all traits except panicle length, spikelet fertility and 100 grain weight under saline condition. The direct positive effects of number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle and spikelet fertility on grain yield under normal and saline environment indicating direct selection of these traits would be effective for increasing grain yield. Under salinity, negative and significant association was shown by stress susceptibility index (SSI) and grain yield in contrast to positive and significant association shown by stress tolerance index (STI) and grain yield. These associations could be useful in identifying salt tolerant and sensitive high yielding genotypes. The lines viz., BIL 108, BIL 752, BIL 1101, BIL 1079, BIL 1094 and BIL 1095 had exhibited higher values of stress tolerance index in salinity.

Key words: Correlation, Path coefficient analysis, Rice, Saltol introgressed lines, SSI, STI.

INTRODUCTION

Rice is considered as a major food crop across major countries worldwide. As a food crop, it forms the staple food for more than three billion people accounting for about 50-80 per cent of their daily calorie intake (Khush, 2005). Rice contributes 43 per cent of total food grain production in India. Although an all-time high production of 104.80 million tonnes of rice was achieved during 2014-15, India needs to produce 120 million tonnes by 2030 to feed its growing population by using less land, water, manpower and input. Conversion of high productive lands for rice cultivation to industrial and residential purposes has pushed rice cultivation to less productive saline, drought and flood prone areas.

In India, salt affected area accounts for 6.73 million hectares of land (Krishnamurthy et al., 2014). The detrimental effects of salinity are through alterations in plant metabolism, reduced water potential, ion imbalances, toxicity and reduction of crop yield leading to total failure of crop. In rice, plant height, total number of tillers, panicle length, grain weight per panicle, 1000-seed weight and quality and quantity of grains decreased progressively with increase in salinity levels. Breeding of saline tolerant varieties necessitates understanding of salinity and its effects on various plant characters in artificially generated populations or natural populations.

Breeders have exploited the high level of salinity tolerance in landraces like Nona Bokra and Pokkali. However, few negative characters of these varieties and the complex traits involved in salinity tolerance have presented challenges for significant progress through conventional breeding. With the advancements in the field of Marker Assisted Selection (MAS), now it is possible to introgress QTLs in the desired genetic background. Using this strategy, several improved versions of rice varieties viz., Swarna Sub1, Samba Mahsuri Sub1, CR 1009 Sub1 and improved versions of Samba Mahsuri and Pusa Basmati exhibiting resistance against BLB have been developed. This demonstrated the feasibility of developing improved rice varieties exhibiting salinity tolerance. The initial MAS derived back cross lines for Saltol were developed using FL 478 as the donor due to its high level of tolerance, but without the tallness, photoperiod sensitivity, and late flowering of the original Pokkali. The MAS derived Backcross Inbred lines (BIL) developed with the FL 478 Saltol allele in the background of popular rice varieties ADT 37 and CR 1009 Sub 1 were used in the present study.
The knowledge of association of component characters with yield has a great importance to plant breeders, as it helps in selection with more precision and accuracy (Ratna et al., 2015) for the improvement of yield. Character association derived by correlation coefficients, forms the basis for selecting the desirable plant, aiding in evaluation of various component characters on grain yield. But selection based on correlation without taking into consideration the interactions between the component characters may sometimes mislead. Therefore, the technique of path coefficient analysis is utilized to have an idea of direct and indirect contribution of a trait towards the yield.

The present investigation was carried out to understand the effects of salinity on genetic variability, correlation, direct and indirect influences and stress indices of grain yield with important yield components in backcross inbred lines (BC$_F^1$) of rice.

**MATERIALS AND METHODS**

The experimental materials consisted of 32 Saltol introgressed backcross inbred lines (BC$_F^1$) of ADT 37 x FL 478 (20 lines) and CR1009 Sub 1 x FL 478 (12 lines) along with the recurrent parents ADT 37 and CR1009 Sub 1, a saline tolerant parent, FL 478 and a susceptible check IR 29. These lines were evaluated in a RBD with two replications during rabi, 2016 under normal condition at Agricultural College and Research Institute, Madurai (EC$_{iw}$ - 0.74 dSm$^{-1}$) and in saline condition farmers field at Vedapatti, Tuticorin District, Tamil Nadu (EC$_{iw}$ - 6 dSm$^{-1}$). The plot size was 3 m x 1 m with spacing of 20 cm between rows and 10 cm between plants. Recommended package of practices were followed. Salinity stress was imposed from 15 days after sowing by irrigating saline water. The data were recorded for 11 quantitative traits on ten random plants per entry in each repetition viz., days to 50 per cent flowering, days to maturity, plant height, number of tillers per plant, number of productive tillers per plant, panicle length, number of total grains per panicle, number of fertile grains per panicle, spikelet fertility, 100 grain weight and single plant yield. The days to 50% flowering, days to maturity and grain yield were recorded on plot basis.

The analysis of variance and their significance for all the characters were worked out as suggested by Panse and Sukhatme (1964). The genotypic correlations between yield and its component traits and among themselves were worked out as per the method suggested by Johnson et al. (1955). The relative influence of yield components on yield by themselves (direct effects) and through other traits (indirect effects) was evaluated by the method of Dewey and Lu (1959). The simple correlation coefficients already estimated at genotypic level were utilized for this purpose. Stress tolerance indices were calculated using the following relationships

\[ SSI = (1 - Y_s / Y_p) / SI \]

(Fischer and Maurer, 1978)

Where, SI is stress intensity and Ys and Yp are mean of all genotypes under stress and non-stress conditions respectively.

\[ STI = (Y_p / Y_s) (Y_s / Y_p) (Y_s / Y_p) = (Y_p / Y_s) / Y_p \]

(Fernandez, 1992)

**RESULTS AND DISCUSSION**

**Analysis of Variance (ANOVA):** Analysis of variance revealed significant differences among the lines for all the traits thus suggesting the presence of sufficient genetic variation among the lines and offers scope for improving salinity tolerance.

**Correlation studies:** The interrelationships among the 11 characters were estimated through genotypic and phenotypic correlation coefficient and the results are presented in Table 1. In general, genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficients. The lower estimates of phenotypic correlation coefficients indicate that the relations were affected least by the environment at the phenotypic level.

Grain yield is a complex trait and jointly determined by a number of related traits. Grain yield per plant had high significant and positive correlation with days to 50 per cent flowering (0.363 and 0.362), plant height (0.596 and 0.593), number of tillers per plant (0.913 and 0.903), number of productive tillers per plant (0.904 and 0.897), days to maturity (0.305 and 0.304), number of total grains per panicle (0.359 and 0.324), number of filled grains per panicle (0.549 and 0.449) and spikelet fertility (0.502 and 0.324) both at genotypic and phenotypic levels respectively under normal environment. A positive significant estimate of correlation indicates strong association of these traits with yield. Therefore, selection for these traits will be useful in improving grain yield.

Under saline condition, grain yield per plant had high significant and positive association with number of tillers per plant (0.409 and 0.407), number of productive tillers per plant (0.496, 0.495), number of total grains per panicle (0.394 and 0.384) and number of filled grains per panicle (0.624 and 0.623). These results clearly indicate that selection of genotype under normal and saline conditions were entirely different. The differential responses exhibited by the traits under salinity stress might be due to the complexity of the traits associated with the stress. As grain yield is a complex trait governed by many traits with large environmental influence which along with salinity tolerance also being a complex trait governed by multi genes makes improvement of yield under salinity stress conditions a tough challenge.
Table 1: Genotypic (G) and phenotypic correlations for yield and its contributing traits in control and saline environments

| Characters               | Correlation | Environments | DFF                  | PH                  | NT                  | NPT                  | PL                  | DM                  | NFG                  | NTG                  | SF                  | HGW                  | SPY                  |
|--------------------------|-------------|--------------|----------------------|---------------------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Days to 50 per cent flowering | G Normal    | 1.00         | 0.716**              | 0.427**             | 0.420**             | 0.871**              | 0.966**              | 0.076                | 0.280                | -0.164               | -0.177               | 0.363*               | -0.177               | 0.363*               |
|                          | P Normal    | 1.00         | 0.712**              | 0.418**             | 0.538**             | 0.964**              | 0.054                | 0.243                | -0.102               | -0.165               | 0.362*               | -0.177               | 0.362*               |
|                          | Saline      | 1.00         | 0.745**              | 0.588**             | 0.486**             | -0.503**             | 0.972**              | -0.221               | -0.339**             | -0.341               | -0.413**             | 0.082               |                      |
| Plant height             | G Normal    | 1.00         | 0.525**              | 0.495**             | 0.673**             | 0.714**              | 0.510**              | 0.530**              | 0.288                | -0.090               | 0.596**              |                      |                      |
|                          | P Normal    | 1.00         | 0.533**              | 0.583**             | -0.463**            | 0.781**              | -0.130               | -0.108               | -0.385               | -0.439**             | 0.162               |                      |                      |
|                          | Saline      | 1.00         | 0.513**              | 0.485**             | 0.432**             | 0.709**              | 0.392**              | 0.452**              | 0.170                | -0.073               | 0.593**              |                      |                      |
| Number of tillers        | G Normal    | 1.00         | 0.570**              | 0.406**             | 0.755**             | -0.123               | 0.339**              | -0.339**             | 0.170                | -0.073               | 0.593**              |                      |                      |
|                          | P Normal    | 1.00         | 0.571**              | 0.407**             | 0.755**             | -0.123               | 0.339**              | -0.339**             | 0.170                | -0.073               | 0.593**              |                      |                      |
|                          | Saline      | 1.00         | 0.570**              | 0.406**             | 0.755**             | -0.123               | 0.339**              | -0.339**             | 0.170                | -0.073               | 0.593**              |                      |                      |
| Panicle length           | G Normal    | 1.00         | 0.514**              | 0.305**             | 0.414**              | 0.391                | 0.186                | 0.172                | 0.186                | -0.285               | 0.913**              |                      |                      |
|                          | P Normal    | 1.00         | 0.514**              | 0.305**             | 0.414**              | 0.391                | 0.186                | 0.172                | 0.186                | -0.285               | 0.913**              |                      |                      |
|                          | Saline      | 1.00         | 0.514**              | 0.305**             | 0.414**              | 0.391                | 0.186                | 0.172                | 0.186                | -0.285               | 0.913**              |                      |                      |
| Number of productive tillers | G Normal   | 1.00         | 0.459**              | 0.385**             | 0.163               | 0.159                | -0.219               | 0.904**              |                      |                      |                      |                      |                      |
|                          | P Normal    | 1.00         | 0.459**              | 0.385**             | 0.163               | 0.159                | -0.219               | 0.904**              |                      |                      |                      |                      |                      |
|                          | Saline      | 1.00         | 0.459**              | 0.385**             | 0.163               | 0.159                | -0.219               | 0.904**              |                      |                      |                      |                      |                      |
| Days to maturity         | G Normal    | 1.00         | 0.304**              | 0.125**             | -0.095              | -0.242               | 0.195                |                      |                      |                      |                      |                      |                      |
|                          | P Normal    | 1.00         | 0.304**              | 0.125**             | -0.095              | -0.242               | 0.195                |                      |                      |                      |                      |                      |                      |
|                          | Saline      | 1.00         | 0.304**              | 0.125**             | -0.095              | -0.242               | 0.195                |                      |                      |                      |                      |                      |                      |
| Number of filled grains  | G Normal    | 1.00         | 0.546**              | 0.393**             | 0.637**             | 0.672**              | 0.016                |                      |                      |                      |                      |                      |                      |
|                          | P Normal    | 1.00         | 0.546**              | 0.393**             | 0.637**             | 0.672**              | 0.016                |                      |                      |                      |                      |                      |                      |
|                          | Saline      | 1.00         | 0.546**              | 0.393**             | 0.637**             | 0.672**              | 0.016                |                      |                      |                      |                      |                      |                      |
| Number of total grains   | G Normal    | 1.00         | 0.034                | 0.125**             | -0.095              | -0.242               | 0.195                |                      |                      |                      |                      |                      |                      |
|                          | P Normal    | 1.00         | 0.034                | 0.125**             | -0.095              | -0.242               | 0.195                |                      |                      |                      |                      |                      |                      |
|                          | Saline      | 1.00         | 0.034                | 0.125**             | -0.095              | -0.242               | 0.195                |                      |                      |                      |                      |                      |                      |
| Spikelet fertility       | G Normal    | 1.00         | 0.406**              | 0.393**             | 0.637**             | 0.672**              | 0.016                |                      |                      |                      |                      |                      |                      |
|                          | P Normal    | 1.00         | 0.406**              | 0.393**             | 0.637**             | 0.672**              | 0.016                |                      |                      |                      |                      |                      |                      |
|                          | Saline      | 1.00         | 0.406**              | 0.393**             | 0.637**             | 0.672**              | 0.016                |                      |                      |                      |                      |                      |                      |
| Hundred grain weight     | G Normal    | 1.00         | 0.073                | -0.194              | 0.359               |                      |                      |                      |                      |                      |                      |                      |                      |
|                          | P Normal    | 1.00         | 0.073                | -0.194              | 0.359               |                      |                      |                      |                      |                      |                      |                      |                      |
|                          | Saline      | 1.00         | 0.073                | -0.194              | 0.359               |                      |                      |                      |                      |                      |                      |                      |                      |
| Single Plant Yield       | G Normal    | 1.00         | 0.357                | 0.329**             | 0.394               |                      |                      |                      |                      |                      |                      |                      |                      |
|                          | P Normal    | 1.00         | 0.357                | 0.329**             | 0.394               |                      |                      |                      |                      |                      |                      |                      |                      |
|                          | Saline      | 1.00         | 0.357                | 0.329**             | 0.394               |                      |                      |                      |                      |                      |                      |                      |                      |

Table r value : 5%-0.296 1%-0.409  * Significance @ 5% level  **Significance @ 1% level

DFF=Days to 50 % flowering, PH=Plant height, NT=Number of tillers per plant, NPT=Number of productive tillers per plant, PL=Panicle length, DM=Days to maturity, NFG=Number of filled grains per panicle, NTG=Number of total grains per panicle, SF=Spikelet fertility, HGW=Hundred grain weight, SPY=Single plant yield. *=1 % level of significance, **= 5% level of significance.
The observed positive correlation of grain yield with various traits was supported by the findings of earlier workers. Shanthi et al. (2011) had reported significant positive correlation of grain yield with sodic tolerant traits viz., productive tillers per plant, filled grains per panicle, spikelet fertility, total chlorophyll, chlorophyll a/b ratio, chlorophyll stability index, catalase and peroxidase activity. Positive and significant correlation of fertile grains per panicle, panicle length and 1000 seed weight (Biswaajit et al., 2017), number of productive tillers per plant (Chandrashekhar and Shailaja, 2017), kernel breadth, breadth wise expansion ratio and water uptake (Prem kumar et al., 2016) and number of total grains per panicle (Panwar, 2006) with grain yield had also been reported. Hence it might be inferred that these traits could be considered as the most important yield contributing traits in rice.

**Path analysis:** Path coefficient analysis provides an exact picture of the relative importance of direct and indirect effects of each of the component character towards yield. The direct and indirect effects of yield contributing traits on grain yield are given in Table 2.

For grain yield, effects were direct and positive for number of tillers per plant, number of productive tillers per plant, number of total grains per panicle, number of filled grains per panicle, spikelet fertility and 100 grain weight under normal environment and indicated their importance while selecting for improving grain yield. Under salinity stress, days to 50 per cent flowering, plant height, number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle and spikelet fertility had direct and positive effects on grain yield and direct selection of these traits would be effective for increasing grain yield. Under salinity stress, days to 50 per cent flowering had highest positive direct effect on grain yield (3.39) followed by number of productive tillers per plant (0.41).

Positive direct effects of various characters on grain yield observed in the present study are in accordance with the findings of Satish Chandra et al. (2009), Ratna et al. (2015), Ashok et al. (2016) and Santhi Priya et al. (2017).

**Indirect effects:** Days to 50 per cent flowering, plant height and panicle length showed direct but negative effects on grain yield per plant under normal environment. But these characters had contributed for the improvement in grain yield indirectly through number of total tillers per plant and number of productive tillers per plant.

Under salinity, total number of grains showed direct but negative effect on grain yield per plant. But it contributed through high positive indirect effect through days to maturity (1.37) and number of filled grains per panicle (0.51) for grain yield improvement. Hence, for the traits which are having significant positive genotypic association with grain yield but negative direct effects, selection should be practiced for the traits which are having positive indirect effects.

**Stress indices:** The stress indices were used to select best salt tolerant lines from 32 Saltol introgressed lines. The stress susceptibility index (SSI) values for grain yield ranged from 0.15 (BIL 1070) to 2.09 (IR 29), whereas the stress tolerance index (STI) values for grain yield ranged from 0.31 (BIL 114) to 1.15 (BIL 1102) (Table 3) whereas lines with higher

### Table 2: Direct (diagonal) and indirect (off-diagonal) effects of different traits on grain yield in control and saline environments

| Character | Environments | DFF | PH | NT | NPT | PL | DM | NFG | NTG | SF | HGW | Genotypic correlation |
|-----------|--------------|-----|----|----|-----|----|----|-----|-----|----|-----|-----------------------|
| DFF       | Normal       | -0.053 | -0.112 | 0.205 | 0.206 | -0.017 | 0.153 | 0.014 | 0.049 | -0.023 | -0.059 | 0.36** |
|           | Saline       | 3.387 | 0.135 | 0.036 | 0.020 | 0.134 | -3.771 | -0.134 | 0.089 | -0.048 | 0.054 | 0.084 |
| PH        | Normal       | -0.038 | -0.157 | 0.252 | 0.243 | -0.013 | 0.113 | 0.092 | 0.094 | 0.041 | -0.030 | 0.596** |
|           | Saline       | 2.636 | 0.173 | 0.031 | 0.236 | 0.115 | -2.982 | -0.078 | 0.028 | -0.051 | 0.053 | 0.162 |
| NT        | Normal       | -0.023 | -0.082 | 0.480 | 0.489 | -0.0085 | 0.061 | 0.033 | 0.030 | 0.026 | -0.095 | 0.913** |
|           | Saline       | 2.063 | 0.092 | 0.059 | 0.327 | 0.098 | -2.338 | 0.120 | -0.029 | -0.023 | 0.041 | 0.409** |
| NPT       | Normal       | -0.022 | -0.078 | 0.478 | 0.491 | -0.009 | 0.061 | 0.029 | 0.028 | 0.022 | -0.098 | 0.904** |
|           | Saline       | 1.684 | 0.101 | 0.048 | 0.406 | 0.083 | -1.962 | 0.182 | -0.040 | -0.035 | 0.029 | 0.496 |
| PL        | Normal       | -0.046 | -0.106 | 0.212 | 0.225 | -0.019 | 0.136 | 0.017 | 0.048 | -0.030 | -0.122 | 0.315* |
|           | Saline       | -1.824 | -0.080 | -0.023 | -0.136 | -0.248 | 2.186 | 0.259 | -0.111 | 0.091 | -0.094 | 0.019 |
| DM        | Normal       | -0.051 | -0.112 | 0.188 | 0.189 | -0.017 | 0.158 | 0.003 | 0.049 | -0.035 | -0.068 | 0.305* |
|           | Saline       | 3.346 | 0.135 | 0.036 | 0.209 | 0.142 | -3.817 | -0.154 | 0.092 | -0.049 | 0.060 | 0.001 |
| NFG       | Normal       | -0.004 | -0.080 | 0.089 | 0.080 | -0.002 | 0.003 | 0.180 | 0.132 | 0.170 | -0.020 | 0.549** |
|           | Saline       | -0.760 | -0.023 | 0.012 | 0.124 | -0.108 | 0.986 | 0.597 | -0.217 | 0.069 | -0.056 | 0.624** |
| NTG       | Normal       | -0.015 | -0.083 | 0.082 | 0.078 | -0.005 | 0.044 | 0.135 | 0.177 | 0.010 | -0.064 | 0.359* |
|           | Saline       | -1.177 | -0.019 | 0.007 | 0.063 | -0.107 | 1.371 | 0.505 | -0.256 | 0.047 | -0.040 | 0.394** |
| SF        | Normal       | 0.009 | -0.045 | 0.089 | 0.078 | 0.004 | -0.039 | 0.216 | 0.013 | 0.142 | 0.035 | 0.502** |
|           | Saline       | -1.230 | -0.067 | -0.010 | -0.107 | -0.172 | 1.414 | 0.313 | -0.092 | 0.131 | -0.082 | 0.009 |
| HGW       | Normal       | 0.009 | 0.014 | -0.137 | -0.143 | 0.007 | -0.032 | -0.011 | -0.034 | 0.015 | 0.333 | 0.021 |
|           | Saline       | -1.523 | -0.076 | -0.020 | -0.099 | -0.194 | 1.906 | 0.277 | -0.084 | 0.089 | -0.120 | 0.156 |

Residual effect – Normal- 0.229  saline- 0.449  * Significance @ 5% level  **Significance @ 1% level

DFF=Days to 50% flowering, PH=Plant height, NT=Number of tillers per plant, NPT=Number of productive tillers per plant, PL=Panicle length, DM=Days to maturity, NFG=Number of filled grains per panicle, NTG=Number of total grains per panicle, SF=Spikelet fertility, HGW=Hundred grain weight, SPY=Single plant yield.
| Introgressed lines | No. of tillers | Prod. tillers | filled grains | Prod. filled grains | Plant height | filled grains yield | STI |
|------------------|---------------|--------------|---------------|---------------------|-------------|---------------------|-----|
| BIL 33           | 94.56         | 12.33        | 40.59         | 0.59                | 1.37        | 0.37                | 0.43|
| BIL 4            | 80.56         | 12.33        | 40.59         | 0.59                | 1.37        | 0.37                | 0.43|
| BIL 57           | 68.56         | 12.33        | 40.59         | 0.59                | 1.37        | 0.37                | 0.43|
| BIL 111          | 80.12         | 12.33        | 40.59         | 0.59                | 1.37        | 0.37                | 0.43|
| BIL 115          | 80.12         | 12.33        | 40.59         | 0.59                | 1.37        | 0.37                | 0.43|
| BIL 117          | 81.89         | 12.67        | 41.67         | 0.61                | 1.39        | 0.38                | 0.41|
| BIL 119          | 81.89         | 12.67        | 41.67         | 0.61                | 1.39        | 0.38                | 0.41|
| BIL 137          | 79.49         | 12.67        | 41.67         | 0.61                | 1.39        | 0.38                | 0.41|
| BIL 598          | 68.06         | 12.67        | 41.67         | 0.61                | 1.39        | 0.38                | 0.41|
| BIL 752          | 72.52         | 13.00        | 42.00         | 0.62                | 1.40        | 0.39                | 0.42|
| BIL 772          | 72.52         | 13.00        | 42.00         | 0.62                | 1.40        | 0.39                | 0.42|
| BIL 1050         | 70.38         | 13.00        | 42.00         | 0.62                | 1.40        | 0.39                | 0.42|
| BIL 1053         | 70.38         | 13.00        | 42.00         | 0.62                | 1.40        | 0.39                | 0.42|
| BIL 1058         | 70.38         | 13.00        | 42.00         | 0.62                | 1.40        | 0.39                | 0.42|
| BIL 1068         | 70.38         | 13.00        | 42.00         | 0.62                | 1.40        | 0.39                | 0.42|
| BIL 1069         | 70.38         | 13.00        | 42.00         | 0.62                | 1.40        | 0.39                | 0.42|
| BIL 1076         | 89.90         | 14.00        | 43.00         | 0.63                | 1.41        | 0.40                | 0.43|
| BIL 1079         | 89.90         | 14.00        | 43.00         | 0.63                | 1.41        | 0.40                | 0.43|
| BIL 1091         | 96.19         | 15.00        | 44.00         | 0.64                | 1.42        | 0.41                | 0.44|
| BIL 1095         | 92.53         | 15.00        | 44.00         | 0.64                | 1.42        | 0.41                | 0.44|
| BIL 1096         | 92.53         | 15.00        | 44.00         | 0.64                | 1.42        | 0.41                | 0.44|
| BIL 1100         | 92.53         | 15.00        | 44.00         | 0.64                | 1.42        | 0.41                | 0.44|
| ADT 37           | 85.13         | 16.00        | 45.00         | 0.65                | 1.43        | 0.42                | 0.45|
| CR 1009          | 89.14         | 16.00        | 45.00         | 0.65                | 1.43        | 0.42                | 0.45|
| FL 478           | 92.53         | 16.00        | 45.00         | 0.65                | 1.43        | 0.42                | 0.45|
| BR 29            | 82.50         | 16.00        | 45.00         | 0.65                | 1.43        | 0.42                | 0.45|
| Mean             | 86.81         | 15.00        | 45.00         | 0.65                | 1.43        | 0.42                | 0.45|

**Table 3:** Salinity stress susceptibility (SSS) and salinity stress tolerance (STT) indices for yield and yield component characters in backcross introgressed lines.
grain yield fell in between these values under high salinity. The lines BIL 108, BIL 752, BIL 1101, BIL 1079, BIL 1094 and BIL 1095 had also exhibited higher values of STI. According to Fischer and Maurer (1978), genotypes experiencing minimum yield reduction under stress compared to normal conditions are distinguished by SSI. Lower values of SSI indicate lower differences in yield across stress and normal environments and hence more stability thereby indicating better performing genotypes under stress were also possessing substantial degree of plasticity to respond to the potential environment. The higher values of STI indicate superiority of genotypes having both higher yield potential and stress tolerance.

Under salinity, negative and significant association ($r = -0.85 **$) was shown by SSI and grain yield in contrast to positive and significant association ($r = 0.97 **$) exhibited by STI and grain yield. This indicated better utility of STI in identifying higher yielding saline tolerant lines across environments. These associations could be useful in identifying salt tolerant and sensitive high yielding genotypes. The stress susceptible and stress tolerance indices indicate that the genotypes developed for salinity tolerance could exhibit better tolerance, adaptability and suitability.

CONCLUSION

Among the 11 yield traits, grain yield per plant and productive tillers per plant were most affected by salinity. Under salinity stress, days to 50 per cent flowering, plant height, number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle and spikelet fertility had direct positive direct effects on grain yield. Hence, direct selection of these traits would be effective for increasing grain yield. Negative and significant association was shown by SSI and grain yield in contrast to positive and significant association between STI and grain yield. This indicates STI can be more useful in identifying high yielding and saline tolerant lines. The lines viz., BIL 108, BIL 752, BIL 1101, BIL 1102, BIL 1079, BIL 1094 and BIL 1095 had exhibited higher values of STI in saline situation. The higher values of STI indicate superiority of these lines having both higher yield potential and stress tolerance.

ACKNOWLEDGEMENT

The authors sincerely acknowledge the Department of Biotechnology (DBT), New Delhi, India for providing financial assistance for conducting the research under BIO-CARE programme.

REFERENCES

Ashok, S., Jyothula, D.P.B. and Ratnababu. D. (2016). Character association and path analysis for yield components and grain quality parameters of rice (Oryza sativa L.). International Journal of Agricultural Science and Research, 6:253-258.

BiswaJit, P., Sritama,K. and Sabyasachi, K. (2017). Genetic variability and character association for yield and yield components in submergence tolerant rice varieties. Indian J. Agric. Res., 51:239-244.

Chandrashekhar, H and Shailaja, H. (2017). Character association and path coefficient analysis for yield component traits in rice (Oryza sativa L.) under moisture stress condition at vegetative stage. Curr. trends biomedical Eng. and Biosci., 2: 1-4.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J., 51:515–518.

Fernandez, G.C.J. (1992). Effective selection criteria for assessing plant stress tolerance. Proceedings of the International Symposium on Adaptation of Vegetables and other Food Crops in Temperature and Water Stress, August 13-16, 1992, Shanhua, Taiwan, pp: 257-270.

Fischer, R.A. and Maurer, R. (1978). Drought resistance in spring wheat cultivars. I. Grain yield responses. Aust. J.Agric. Res., 29: 897–912.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955) Estimation of genetic and environmental variability in soybeans. Agronomy J., 47: 314–318.

Khush, G.S. (2005). What it will take to feed 5.0 billion rice consumers in 2030. Plant Mol Biol., 59: 1–6.

Panwar, L.L. (2006). Character association and path analysis in rice (Oryza sativa L.). Ann. agric. Res. New series, 27: 257-260.

Premkumar, R., Gnamamalar, R. P. and Anandakumar, C. R. (2016).Correlation and path coefficient analysis of grain quality traits in Rice (Oryza sativa L.). Indian J.Agri.Res., 50: 27-32.

Ratna, M., Begum, S., Husna, A., Dey, S. R. and Hossain, M. S. (2015). Correlation and path coefficients analyses in basmati rice. Bangladesh J. Agril. Res., 40: 153-161.

Shanthi, P, Jebaraj, S and Geetha, S. (2011). Correlation and path coefficient analysis of some sodic tolerant physiological traits and yield in rice (Oryza sativa L.). Indian J. Agric. Res., 45: 201-208.

Satish Chandra, B., Dayakar Reddy, T., Ansari, N. A. and Sudheer Kumar, S. (2009). Correlation and path analysis for yield and yield components in rice (Oryza sativa L.). Agric. Sci. Digest, 29: 45-47.