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# Evaluation of Exotic Rice Germplasm (*Oryza sativa* L) for Correlation and Path Coefficient Analysis for Seed Yield Attributing Traits

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Thirty seven rice germplasm were evaluated to assess genetic variability, heritability, genetic advance, correlation and path coefficient analysis for 17 quantitative characters. The experimental results concluded that TP-29632, followed by TP-30015, TP-29637, SHUATS DHAN-2 and TP-30025 was found to be superior in grain yield among 37 exotic rice genotypes**.** IRRI-5 (TP-29632), IRRI-10 (TP-30015) and IRRI-21(TP-29759) recorded early maturity among 37 genotypes. Grain yield per hill was positively and significantly associated with flag leaf width, number of tillers per hill, number of panicles per hill, number of spikelets per panicle, number of filled grains, grain weight, biological yield, harvest index at both genotypic and phenotypic levels. Biological yield, harvest index, number of panicles per hill, plant height, flag leaf width recorded positive direct effect on grain yield per hill at both phenotypic and genotypic levels.

*Keywords: Rice; cereal food; germplasm; grain yield.*

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## 1. INTRODUCTION

Rice (*Oryza sativa* L) is one of the most important staple cereal food crop consumed by almost half of the world's population and belongs to the genus *Oryza* of family Graminae (Poaceae). Rice is also known as the "Grain of Life" because it being the staple food and source of livelihood for 120-150 million rural households and it is a back bone in the Indian agriculture (Singh *et al.,* 2018). India is largest rice breeding country in the world. However, its productivity per unit area by world's standard is low. In order to increase rice productivity, high yielding, early maturing and disease resistance varieties should be developed. Breeding strategies is chiefly influenced by the choice of germplasm. Any wrong choice of germplasm to initiate the selection process results in the resources [1,2]. The systematic breeding program involves steps like creating genetic variability practising selection and utilization of selected genotypes to evolve promising varieties. In a rice improvement program, it is a germplasm, which virtually determine the success and nature of end product. Correlation may help the plant breeder to know how the improvement of one character will bring simultaneous improvement in other characters [3,4]. Path coefficient analysis standard regression coefficient and measures the direct influence of one variable upon the other. Hence, objectives of the present study is to asses genetic variability parameters for evaluation of exotic rice germplasm yield and early maturity among 37 genotypes and to study correlation between yield and yield attributing characters and to study direct and indirect effects of yield contributing characters on grain yield. Rice is grown in almost all the states in the country however the major states I rice production are West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab and Tamil Nadu. In India rice is grown in 44.7 million ha, the production level is 117.5 million tons and the average productivity of 3.6-4.2 ton/ha during 2019-2020. The total production of rice during 2019-2020 is estimated at record 117.47 million tons, if it is higher by 9.67 million tons than the five years average production of 107.80 million tons. (Annual Report 2019-2020, Ministry of Agriculture and Farmer's Welfare, GOI) [5-7]. The purpose of this research is to evaluate exotic rice germplasm (*Oryza sativa* L) for correlation and path coefficient analysis for seed yield attribution traits.

## 2. MATERIALS AND METHODS

The existing study was conducted at the Field Experimentation Centre at Department of Genetics and Plant Breeding, Naini Agricultural Institute, SHUATS, Prayagraj, U.P., during *Kharif*-2020 The experimental material consists of 37 rice genotypes and one check variety laid in a Randomized Block Design (RBD) with 3 replications each. Recommended packages of practices were followed for superior crop growth. The data were recorded five randomly selected plants from each replication leaving the first two borders rows from all the four sides, in order to avoid the sampling error. The observations were recorded as per the following procedure. Readings from five plants were averaged replication wise and the mean data was used for statistical analysis for 16 character. Correlation coefficient analysis and Path coefficient analysis was calculated by the formula given by Al Jibouri et al., (1958) and Dewey and Lu, [8]. Rice has shaped the culture, diets and economic of thousands of millions of people, for more than half of the humanity "Rice is Life". Considering its important position, the United Nations designated year 2004 as the "International Year of Rice" (Fresco, L. 2015). Rice is life was the theme of international year of 2004 denoting its overwhelming importance as an item of food and commerce (Pandey et al, 2010).

Thirty-seven rice genotypes are grown in Randomized Block Design (RBD) with three replications during *Kharif*-2020.

Design of Experiment: RBD
No. of Genotypes: 37
No. of Replications: 3
Date of Sowing: 26 June, 2020
Date of Transplanting: 17 July, 2020
Size of each bund: 0.5
Gross Cultivated Area: 230$m^2$
Net Cultivated Area: 216$m^2$
Row to Row Spacing: 20 cm
Plant to Plant Spacing: 15 cm
Date of Harvesting: 26 oct, 2020

## 3. RESULTS AND DISCUSSION

37 genotypes of rice showed a significant difference among all the characters studied. The experimental results concluded that TP-29632, followed by TP-30015, TP-29637, SHUATS DHAN-2 and TP- 30025 was found to be superior in grain yield among 37 exotic rice genotypes**.** IRRI-5 (TP-29632), IRRI-10 (TP-

30015) and IRRI-21(TP-29759) recorded early maturity among 37 genotypes. Grain yield per hill showed the positive significant phenotypic association with flag leaf width (0.194*), number of tillers per hill (0.348**), number of panicles per hill (0.332**), number of spikelets per panicles (0.306**), number of filled grains per panicles (0.329**), grain weight per panicle (0.613**), biological yield (0.736**), harvest index (0.679**). The correlation does not show negative significant. The characters like plant height (0.168), flag leaf length (0.111), panicle length (0.024), correlation shows positive non-significant. The correlation for days to 50% flowering (-0.145), days to maturity (-0.077), number of unfilled grains per panicle (-0.002), test weight (-0.035), shows negative non-significant. The positive correlation of grain yield with various traits like spikelets per panicle was supported by Fiyaz et al. [9]. Similar results are reported by Rashmi et al. [10], Shiva et al. [11], Abdul et al. [12] for test weight, harvest index, no. of spikelet/panicle. Aditya et al. [13] for test weight, Roy et al. [14] for number of tillers per hill and number of spikelets per panicle Ramesh et al. (2013) for test weight, Roy et al. [14] for harvest index, by Roy et al. [14] for number of tillers per hill and number of spikelets per panicle. In the present study, genotypic and phenotypic correlation was higher in magnitude than the phenotypic correlation coefficient. This indicates that these characters are positively governed by additive of gene action and are useful in improvement.

**Table 1. List of 37 genotypes**

| S.No. | GENOTYPES | DESIGNATION |
|---|---|---|
| 1 | IRRI-1 | TP-29631 |
| 2 | IRRI-2 | TP-29637 |
| 3 | IRRI-3 | TP-29651 |
| 4 | IRRI-4 | TP-29654 |
| 5 | IRRI-5 | TP-29632 |
| 6 | IRRI-6 | TP-30047 |
| 7 | IRRI-7 | TP-30433 |
| 8 | IRRI-8 | TP-29409 |
| 9 | IRRI-9 | TP-30011 |
| 10 | IRRI-10 | TP-30015 |
| 11 | IRRI-11 | TP-29737 |
| 12 | IRRI-12 | TP-30025 |
| 13 | IRRI-14 | TP-30022 |
| 14 | IRRI-16 | TP-30035 |
| 15 | IRRI-17 | TP-30082 |
| 16 | IRRI-20 | TP-29759 |
| 17 | IRRI-21 | TP-30430 |
| 18 | IRRI-22 | TP-30431 |
| 19 | IRRI-23 | TP-30432 |
| 20 | IRRI-24 | TP-30436 |
| 21 | IRRI-25 | TP-30438 |
| 22 | IRRI-26 | TP-30439 |
| 23 | IRRI-29 | TP-30441 |
| 24 | IRRI-30 | IRRI-104 |
| 25 | IRRI-31 | IRRI-105 |
| 26 | IRRI-36 | IRRI-174 |
| 27 | IRRI-37 | IRRI-179 |
| 28 | IRRI-39 | IRRI-181 |
| 29 | IRRI-156 | IRRI-35 |
| 30 | SHIATS DHAN-1 | |
| 31 | SHIATS DHAN-2 | |
| 32 | SHIATS DHAN-3 | |
| 33 | SHIATS DHAN-4 | |
| 34 | SHIATS DHAN-5 | |
| 35 | SHIATS DHAN-6 | |
| 36 | SHIATS DHAN-7 | |
| 37 | NDR-359 © | |

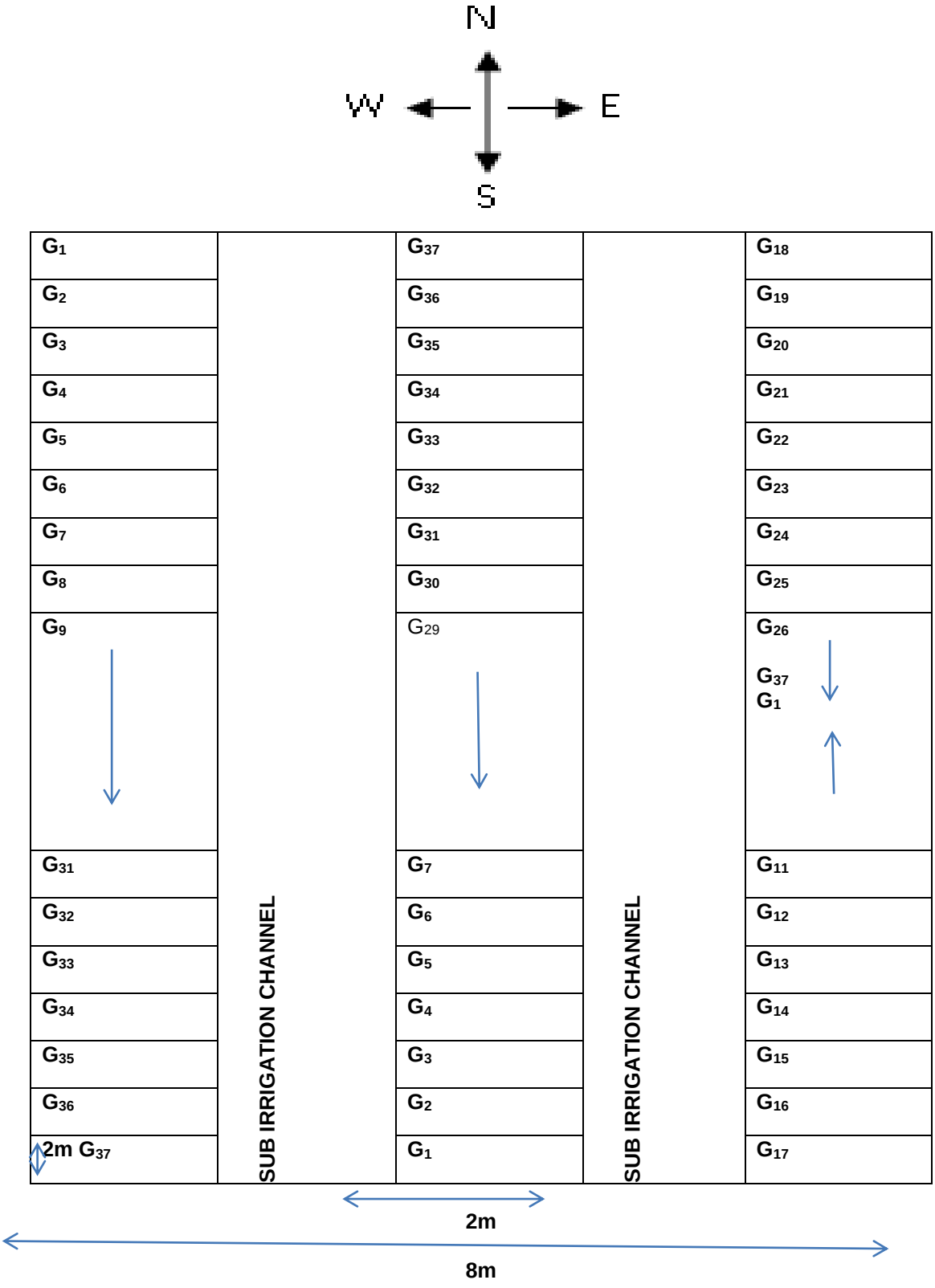


**Fig. 1. Layout of the experimental plot**

**Table 2. Mean Performance of 37 genotypes of rice for 17 quantitative characters grown during *Kharif*-2020**

| Genotypes | Days to 50% floweri ng | Plant height (cm) | Flag leaf length (cm) | Flag leaf width (cm) | No. of tillers/hill | No. of panicles /hill | Panicle length (cm) | Days to maturity | No. of spikelet's /panicle | No. of filled grains | No. of unfilled grains | Grainwt (g) | Biologic al yield(g) | Harvest index (%) | Test wt (g) | Grain yield /hill | Grain yield / hec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IRRI-1 | 89.00 | 144.70 | 49.33 | 1.28 | 11.60 | 10.00 | 29.48 | 119.00 | 143.93 | 117.86 | 26.06 | 2.20 | 57.46 | 34.68 | 21.00 | 19.93 | 6.57 |
| IRRI-2 | 89.00 | 148.20 | 56.96 | 1.28 | 12.13 | 10.53 | 30.980 | 121.00 | 144.93 | 125.66 | 20.86 | 3.333 | 80.933 | 42.76 | 23.00 | 34.60 | 9.41 |
| IRRI-3 | 114.0 | 130.13 | 44.27 | 1.17 | 11.00 | 9.53 | 30.513 | 144.00 | 126.40 | 104.06 | 25.33 | 2.400 | 76.333 | 22.39 | 22.00 | 17.20 | 5.677 |
| IRRI-4 | 89.00 | 129.53 | 37.74 | 1.24 | 12.46 | 10.73 | 29.240 | 120.00 | 114.06 | 91.800 | 22.26 | 2.267 | 65.267 | 42.43 | 20.00 | 27.66 | 7.130 |
| IRRI-5 | 85.00 | 150.53 | 50.30 | 1.45 | 12.80 | 11.53 | 30.680 | 115.00 | 158.80 | 132.33 | 26.46 | 4.533 | 89.933 | 47.89 | 23.00 | 43.20 | 9.25 |
| IRRI-6 | 87.00 | 130.46 | 48.78 | 1.52 | 11.66 | 10.13 | 28.633 | 117.00 | 152.46 | 128.20 | 24.40 | 3.667 | 66.533 | 46.40 | 21.00 | 30.86 | 8.18 |
| IRRI-7 | 86.00 | 146.01 | 52.53 | 1.26 | 12.86 | 11.46 | 27.360 | 116.00 | 139.53 | 112.66 | 26.86 | 3.133 | 77.800 | 35.22 | 24.00 | 27.40 | 7.043 |
| IRRI-8 | 90.00 | 145.43 | 44.10 | 1.23 | 11.33 | 10.00 | 29.847 | 122.00 | 151.26 | 123.93 | 27.26 | 2.600 | 72.800 | 37.23 | 23.00 | 27.13 | 7.953 |
| IRRI-9 | 90.00 | 140.80 | 46.43 | 1.18 | 11.46 | 10.26 | 28.267 | 120.00 | 116.33 | 92.86 | 24.66 | 2.467 | 71.467 | 40.13 | 21.99 | 28.60 | 6.440 |
| IRRI-10 | 85.00 | 141.83 | 46.04 | 1.20 | 11.86 | 10.66 | 26.133 | 115.00 | 130.06 | 104.13 | 25.93 | 3.533 | 74.533 | 49.08 | 23.99 | 36.60 | 10.07 |
| IRRI-11 | 95.00 | 138.86 | 41.43 | 1.14 | 12.53 | 10.73 | 26.380 | 125.00 | 132.00 | 106.53 | 25.46 | 2.600 | 63.400 | 39.34 | 20.00 | 24.93 | 6.227 |
| IRRI-12 | 91.00 | 139.00 | 43.87 | 1.14 | 10.80 | 9.00 | 29.047 | 121.00 | 143.73 | 117.86 | 25.86 | 3.533 | 63.467 | 49.77 | 23.00 | 31.60 | 8.42 |
| IRRI-14 | 90.00 | 140.16 | 44.99 | 1.287 | 11.53 | 10.26 | 27.420 | 120.00 | 152.26 | 119.66 | 32.40 | 3.333 | 68.133 | 40.50 | 24.00 | 27.33 | 7.020 |
| IRRI-16 | 94.00 | 151.73 | 44.16 | 1.38 | 12.46 | 11.13 | 26.640 | 124.00 | 128.53 | 104.06 | 25.20 | 3.000 | 77.667 | 41.06 | 25.00 | 31.80 | 8.49 |
| IRRI-17 | 92.00 | 141.93 | 46.16 | 1.30 | 10.40 | 9.13 | 31.187 | 122.00 | 139.20 | 112.60 | 26.86 | 2.867 | 67.533 | 40.50 | 25.00 | 27.33 | 7.020 |
| IRRI-20 | 92.00 | 139.25 | 41.27 | 1.34 | 11.26 | 9.93 | 32.067 | 122.00 | 125.73 | 99.20 | 26.53 | 3.000 | 69.400 | 41.82 | 25.00 | 29.06 | 7.593 |
| IRRI-21 | 76.00 | 131.83 | 44.92 | 1.04 | 12.20 | 11.00 | 28.787 | 106.00 | 113.20 | 92.06 | 28.80 | 2.467 | 51.633 | 40.09 | 25.00 | 20.66 | 6.820 |

| Genotypes | Days to 50% floweri ng | Plant height (cm) | Flag leaf length (cm) | Flag leaf width (cm) | No. of tillers/ hill | No. of panicles /hill | Panicle length(cm) | Days to maturity | No. of spikelet's /panicle | No. of filled grains | No. of unfilled grains | Grain wt (g) | Biologic al yield(g) | Harvest index ( %) | Test wt(g) | Grain yield /hill | Grain yield / hec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IRRI-22 | 90.00 | 140.86 | 49.09 | 1.42 | 11.60 | 10.26 | 31.187 | 120.00 | 134.73 | 107.80 | 27.06 | 3.133 | 74.867 | 39.98 | 22.00 | 29.93 | 7.877 |
| IRRI-23 | 86.99 | 143.73 | 54.46 | 1.18 | 9.400 | 8.13 | 24.033 | 117.00 | 135.06 | 109.66 | 25.76 | 3.467 | 65.800 | 45.23 | 18.99 | 29.73 | 7.813 |
| IRRI-24 | 89.00 | 134.04 | 45.90 | 1.28 | 11.73 | 10.46 | 27.433 | 119.00 | 127.73 | 102.00 | 25.73 | 2.733 | 63.000 | 38.76 | 23.00 | 24.53 | 6.097 |
| IRRI-25 | 89.00 | 143.13 | 45.88 | 1.38 | 10.80 | 9.46 | 30.360 | 120.00 | 144.26 | 113.40 | 29.20 | 3.733 | 62.067 | 43.90 | 26.00 | 27.40 | 7.040 |
| IRRI-26 | 88.00 | 145.66 | 51.26 | 1.41 | 9.133 | 7.93 | 30.407 | 118.00 | 140.06 | 106.33 | 24.80 | 3.133 | 54.200 | 43.32 | 23.00 | 23.53 | 7.763 |
| IRRI-29 | 91.00 | 131.44 | 43.97 | 1.28 | 12.00 | 10.60 | 28.807 | 121.00 | 116.00 | 91.20 | 25.46 | 2.667 | 64.867 | 39.18 | 22.00 | 25.40 | 7.380 |
| IRRI-30 | 86.99 | 132.92 | 47.28 | 1.26 | 11.20 | 9.80 | 30.340 | 116.99 | 124.73 | 98.93 | 25.80 | 3.000 | 56.267 | 45.24 | 24.00 | 25.53 | 8.427 |
| IRRI-31 | 87.00 | 138.33 | 42.30 | 1.25 | 10.00 | 8.73 | 29.567 | 117.00 | 107.66 | 83.06 | 24.60 | 2.333 | 57.200 | 34.25 | 23.00 | 19.53 | 6.443 |
| IRRI-36 | 85.00 | 132.50 | 39.62 | 1.24 | 9.933 | 8.60 | 26.647 | 115.00 | 117.13 | 91.33 | 25.80 | 2.267 | 59.467 | 36.30 | 25.00 | 21.66 | 7.150 |
| IRRI-37 | 87.00 | 145.86 | 56.53 | 1.39 | 11.20 | 9.47 | 26.007 | 117.00 | 115.80 | 87.20 | 28.60 | 2.467 | 59.933 | 43.57 | 24.00 | 26.26 | 6.670 |
| IRRI-39 | 95.00 | 134.53 | 43.96 | 1.63 | 9.267 | 8.13 | 26.647 | 125.00 | 133.60 | 101.73 | 31.86 | 2.933 | 52.400 | 38.14 | 25.00 | 20.06 | 6.620 |
| IRRI-156 | 89.00 | 143.66 | 51.52 | 1.31 | 11.93 | 7.00 | 25.380 | 119.00 | 117.40 | 90.40 | 27.00 | 2.933 | 67.133 | 41.77 | 23.99 | 28.20 | 7.307 |

| Genotypes | Days to 50% floweri ng | Plant height (cm) | Flag leaf length (cm) | Flag leaf width (cm) | No. of tillers/ hill | No. of panicles /hill | Panicle length(cm) | Days to maturity | No. of spikelet's /panicle | No. of filled grains | No. of unfilled grains | Grain wt (g) | Biologic al yield(g) | Harvest index ( %) | Test wt(g) | Grain yield /hill | Grain yield / hec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SHUATS DHAN-1 | 97.99 | 130.11 | 41.56 | 1.86 | 16.60 | 14.06 | 26.827 | 127.99 | 244.33 | 216.64 | 28.34 | 4.600 | 79.663 | 40.11 | 16.00 | 31.92 | 6.53 |
| SHUATS DHAN-2 | 94.00 | 126.81 | 40.30 | 1.50 | 13.40 | 11.26 | 27.903 | 124.00 | 147.33 | 114.20 | 33.26 | 4.057 | 80.460 | 40.14 | 28.99 | 32.25 | 6.64 |
| SHUATS DHAN-3 | 93.00 | 119.84 | 32.66 | 1.23 | 14.24 | 12.23 | 30.197 | 123.00 | 216.33 | 186.32 | 31.59 | 4.120 | 77.330 | 40.88 | 22.00 | 31.58 | 6.50 |
| SHUATS DHAN-4 | 105.0 | 128.60 | 38.53 | 1.66 | 12.40 | 10.73 | 26.530 | 135.00 | 212.32 | 178.46 | 34.31 | 4.020 | 77.530 | 39.08 | 18.00 | 30.30 | 6.00 |
| SHUATS DHAN-5 | 98.00 | 120.77 | 37.96 | 1.40 | 15.40 | 13.06 | 28.703 | 128.00 | 213.11 | 172.46 | 38.95 | 4.527 | 75.127 | 38.99 | 21.00 | 29.29 | 6.663 |
| SHUATS DHAN-6 | 91.00 | 126.47 | 34.86 | 1.42 | 14.20 | 12.17 | 26.560 | 120.99 | 201.62 | 164.28 | 37.62 | 3.620 | 68.130 | 39.99 | 23.99 | 27.25 | 6.993 |
| SHUATS DHAN-7 | 90.00 | 124.54 | 36.73 | 1.38 | 13.88 | 11.63 | 25.400 | 120.00 | 196.84 | 167.98 | 29.81 | 3.860 | 65.480 | 38.81 | 23.00 | 25.42 | 6.390 |
| NDR-359 | 105.0 | 104.66 | 27.63 | 1.36 | 13.66 | 12.300 | 23.86 | 134.00 | 175.26 | 148.66 | 27.05 | 3.917 | 72.330 | 36.57 | 17.53 | 26.45 | 6.00 |
| MEAN | 91.13 | 136.18 | 44.46 | 1.33 | 11.95 | 10.328 | 28.256 | 121.27 | 146.86 | 119.39 | 27.67 | 3.201 | 68.312 | 40.42 | 22.71 | 27.62 | 9.117 |
| Range Minimum | 76.00 | 104.66 | 27.63 | 1.04 | 9.13 | 7.000 | 23.860 | 106.00 | 107.66 | 83.06 | 20.86 | 2.200 | 51.633 | 22.39 | 16.00 | 17.20 | 5.677 |
| Range Maximum | 114.0 | 151.73 | 56.96 | 1.86 | 16.60 | 14.060 | 32.067 | 144.00 | 244.33 | 216.64 | 38.95 | 4.600 | 89.933 | 49.77 | 28.99 | 43.20 | 9.25 |
| C.V | 2.650 | 2.464 | 7.310 | 4.16 | 4.60 | 10.504 | 3.679 | 2.663 | 5.237 | 7.07 | 9.64 | 9.293 | 7.718 | 6.396 | 2.530 | 9.858 | 9.857 |
| S.E | 1.394 | 1.937 | 1.877 | 0.03 | 0.31 | 0.626 | 0.600 | 1.865 | 4.440 | 4.87 | 1.54 | 0.172 | 3.044 | 1.493 | 0.332 | 1.572 | 0.519 |
| C.D 5% | 3.931 | 5.461 | 5.291 | 0.09 | 0.89 | 1.766 | 1.692 | 5.257 | 12.518 | 13.74 | 4.34 | 0.484 | 8.582 | 4.208 | 0.935 | 4.433 | 1.463 |

**Table 3. Phenotypical correlation coefficient between yield and its components traits in rice**

| Traits | PH | FLL | FLW | NTPH | NPPH | PL | DM | NSP | NFGP | NUGP | GW | BY | HI | TW | GYPH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DF (50%) | -0.4333 ** | -0.4153 ** | 0.3072 ** | 0.2306 * | 0.1879 * | -0.093 | 0.8585 ** | 0.3851 ** | 0.3813 ** | 0.2443 ** | 0.2128 * | 0.2839 ** | -0.4827 ** | -0.3934 ** | -0.145 |
| PH | 1 | 0.7781 ** | -0.137 | -0.4536 ** | -0.4083 ** | 0.2636 ** | -0.3743 ** | -0.4717 ** | -0.4659 ** | -0.3644 ** | -0.2998 ** | 0.011 | 0.2212 * | 0.3235 ** | 0.168 |
| FLL | | 1 | -0.047 | -0.4059 ** | -0.3927 ** | 0.2011 * | -0.3713 ** | -0.4422 ** | -0.4319 ** | -0.3556 ** | -0.2389 * | -0.045 | 0.2102 * | 0.1953 * | 0.111 |
| FLW | | | 1 | 0.3130 ** | 0.2194 * | -0.105 | 0.2796 ** | 0.5447 ** | 0.5147 ** | 0.3254 ** | 0.4995 ** | 0.2111 * | 0.044 | -0.2095 * | 0.194* |
| NTPH | | | | 1 | 0.8024 ** | -0.169 | 0.2356 * | 0.6920 ** | 0.6977 ** | 0.3884 ** | 0.5400 ** | 0.5205 ** | -0.052 | -0.3194 ** | 0.348** |
| NPPH | | | | | 1 | -0.059 | 0.1961 * | 0.5765 ** | 0.5853 ** | 0.3237 ** | 0.4323 ** | 0.4748 ** | -0.027 | -0.2930 ** | 0.332** |
| PL | | | | | | 1 | -0.066 | -0.151 | -0.141 | -0.179 | -0.111 | 0.053 | -0.014 | 0.2524 ** | 0.024 |
| DM | | | | | | | 1 | 0.3711 ** | 0.3686 ** | 0.169 | 0.2054 * | 0.3278 ** | -0.4285 ** | -0.3614 ** | -0.077 |
| NSP | | | | | | | | 1 | 0.9869 ** | 0.5338 ** | 0.7700 ** | 0.4079 ** | 0.017 | -0.4308 ** | 0.306** |
| NFGP | | | | | | | | | 1 | 0.4413 ** | 0.7507 ** | 0.4373 ** | 0.019 | -0.4712 ** | 0.329** |
| NUGP | | | | | | | | | | 1 | 0.4183 ** | 0.067 | -0.069 | 0.097 | -0.002 |
| GW | | | | | | | | | | | 1 | 0.5043 ** | 0.3663 ** | -0.1881 * | 0.613** |
| BY | | | | | | | | | | | | 1 | 0.015 | -0.149 | 0.736** |
| HI | | | | | | | | | | | | | 1 | 0.106 | 0.679** |
| TW | | | | | | | | | | | | | | 1 | -0.035 |

*DF: Days to 50%flowring, DM: Days to maturity, FL: Flag leaf length (cm), FW: Flag leaf width, PH: Plant height, TT: No. of total tillers per hill, ET: No of effective tillers per hill, PL: Panicle length, NGPP: No of grains per hill, NFGPP: No of filled grains per panicle, NUGPP: No of unfilled grains per panicle, BYP: Biological yield per panicle, TW: Test weight, HI: Harvest index, GYPP: Grain yield per plant. **1% Level of Significance, * 5% Level of Significance*

**Table 4. Genotypical correlation coefficient between yield and its component traits in rice**

| Traits | PH | FLL | FLW | NTPH | NPPH | PL | DM | NSP | NFGP | NUGP | GW | BY | HI | TW | GYPH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DF (50%) | - 0.469** | -0.470** | 0.333** | 0.279** | 0.268** | -0.101 | 1.081 | 0.421** | 0.420** | 0.254** | 0.246** | 0.427** | -0.570** | -0.418** | -0.107 |
| PH | 1 | 0.843** | -0.178 | -0.511** | -0.528** | 0.266** | -0.462** | -0.498** | -0.496** | -0.483** | -0.351** | -0.020 | 0.299** | 0.339** | 0.205* |
| FLL | | 1 | -0.153 | -0.518** | -0.578** | 0.177 | -0.469** | -0.508** | -0.498** | -0.510** | -0.288** | -0.109 | 0.295** | 0.217* | 0.121 |
| FLW | | | 1 | 0.360** | 0.344** | -0.149 | 0.341** | 0.593** | 0.572** | 0.427** | 0.599** | 0.298** | 0.086 | -0.228* | 0.282** |
| NTPH | | | | 1 | 0.993** | -0.198* | 0.269** | 0.750** | 0.772** | 0.479** | 0.640** | 0.588** | -0.032 | -0.348** | 0.399** |
| NPPH | | | | | 1 | -0.090 | 0.255** | 0.763** | 0.794** | 0.427** | 0.657** | 0.614** | -0.077 | -0.369** | 0.390** |
| PL | | | | | | 1 | -0.067 | -0.164 | -0.153 | -0.255** | -0.144 | 0.069 | -0.013 | 0.275** | 0.046 |
| DM | | | | | | | 1 | 0.427** | 0.428** | 0.278** | 0.235* | 0.424** | -0.607** | -0.427** | -0.133 |
| NSP | | | | | | | | 1 | 0.997** | 0.683** | 0.814** | 0.474** | -0.003 | -0.465** | 0.334** |
| NFGP | | | | | | | | | 1 | 0.617** | 0.803** | 0.499** | -0.011 | -0.513** | 0.347** |
| NUGP | | | | | | | | | | 1 | 0.577** | 0.152 | -0.098 | 0.100 | 0.041 |
| GW | | | | | | | | | | | 1 | 0.628** | 0.368** | -0.236* | 0.699** |
| BY | | | | | | | | | | | | 1 | 0.000 | -0.189* | 0.726** |
| HI | | | | | | | | | | | | | 1 | 0.091 | 0.684** |
| TW | | | | | | | | | | | | | | 1 | -0.065 |

*DF: Days to 50%flowring, DM: Days to maturity, FL: Flag leaf length (cm), FW: Flag leaf width, PH: Plant height, TT: No. of total tillers per hill, ET: No of effective tillers per hill, PL: Panicle length, NGPP: No of grains per hill, NFGPP: No of filled grains per panicle, NUGPP: No of unfilled grains per panicle, BYP: Biological yield per panicle, TW: Test weight, HI: Harvest index, GYPP: Grain yield per plant **1% Level of Significance, * 5% Level of Significance*

**Table 5. Direct (diagonal) and indirect effects of yield component traits on grain yield in rice at phenotypic level**

| Traits | DF (50%) | PH | FLL | FLW | NTPH | NPPH | PL | DM | NSP | NFGP | NUGP | GW | BY | HI | TW | GYPH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DF (50%)** | -0.045 | 0.019 | 0.019 | -0.014 | -0.010 | -0.008 | 0.004 | -0.039 | -0.017 | -0.017 | -0.011 | -0.010 | -0.013 | 0.022 | 0.018 | -0.145 |
| **PH** | -0.014 | **0.032** | 0.025 | -0.004 | -0.014 | -0.013 | 0.008 | -0.012 | -0.015 | -0.015 | -0.012 | -0.010 | 0.000 | 0.007 | 0.010 | 0.168 |
| **FLL** | 0.016 | -0.031 | **-0.039** | 0.002 | 0.016 | 0.016 | -0.008 | 0.015 | 0.017 | 0.017 | 0.014 | 0.009 | 0.002 | -0.008 | -0.008 | 0.111 |
| **FLW** | 0.010 | -0.004 | -0.002 | **0.031** | 0.010 | 0.007 | -0.003 | 0.009 | 0.017 | 0.016 | 0.010 | 0.016 | 0.007 | 0.001 | -0.007 | 0.194* |
| **NTPH** | 0.000 | 0.001 | 0.001 | 0.000 | **-0.001** | -0.001 | 0.000 | 0.000 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | 0.000 | 0.000 | 0.348** |
| **NPPH** | 0.001 | -0.002 | -0.002 | 0.001 | 0.005 | **0.006** | 0.000 | 0.001 | 0.003 | 0.004 | 0.002 | 0.003 | 0.003 | 0.000 | -0.002 | 0.332** |
| **PL** | 0.001 | -0.002 | -0.001 | 0.001 | 0.001 | 0.000 | **-0.006** | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | -0.001 | 0.024 |
| **DM** | -0.020 | 0.009 | 0.009 | -0.006 | -0.005 | -0.005 | 0.002 | **-0.023** | -0.009 | -0.008 | -0.004 | -0.005 | -0.008 | 0.010 | 0.008 | -0.077 |
| **NSP** | -0.014 | 0.017 | 0.016 | -0.020 | -0.025 | -0.021 | 0.006 | -0.014 | **-0.037** | -0.036 | -0.020 | -0.028 | -0.015 | -0.001 | 0.016 | 0.306** |
| **NFGP** | 0.002 | -0.002 | -0.002 | 0.003 | 0.004 | 0.003 | -0.001 | 0.002 | 0.005 | **0.005** | 0.002 | 0.004 | 0.002 | 0.000 | -0.002 | 0.329** |
| **NUGP** | -0.001 | 0.001 | 0.001 | -0.001 | -0.001 | -0.001 | 0.001 | -0.001 | -0.002 | -0.002 | **-0.004** | -0.001 | 0.000 | 0.000 | 0.000 | -0.002 |
| **GW** | 0.007 | -0.010 | -0.008 | 0.017 | 0.018 | 0.015 | -0.004 | 0.007 | 0.026 | 0.025 | 0.014 | **0.034** | 0.017 | 0.012 | -0.006 | 0.613** |
| **BY** | 0.207 | 0.008 | -0.033 | 0.154 | 0.380 | 0.346 | 0.039 | 0.239 | 0.298 | 0.319 | 0.049 | 0.368 | **0.730** | 0.011 | -0.108 | 0.736** |
| **HI** | -0.303 | 0.139 | 0.132 | 0.028 | -0.033 | -0.017 | -0.009 | -0.269 | 0.011 | 0.012 | -0.043 | 0.230 | 0.009 | **0.627** | 0.066 | 0.679** |
| **TW** | 0.007 | -0.006 | -0.004 | 0.004 | 0.006 | 0.005 | -0.005 | 0.007 | 0.008 | 0.009 | -0.002 | 0.003 | 0.003 | -0.002 | **-0.018** | -0.035 |
| **GYPH** | -0.145 | 0.168 | 0.111 | 0.194* | 0.348** | 0.332** | 0.024 | -0.077 | 0.306** | 0.329** | -0.002 | 0.613** | 0.736** | 0.679** | -0.035 | **1.000** |

*DF: Days to 50%flowring, DM: Days to maturity, FL: Flag leaf length (cm), FW: Flag leaf width, PH: Plant height, TT: No. of total tillers per hill, ET: No of effective tillers per hill, PL: Panicle length, NGPP: No of grains per hill, NFGPP: No of filled grains per panicle, NUGPP: No of unfilled grains per panicle, BYP: Biological yield per panicle, TW: Test weight, HI: Harvest index, GYPP: Grain yield per plant*

**Table 6. Direct (diagonal) and indirect effects of yield components traits on grain yield in rice at Genotypic level**

| Traits | DF (50%) | PH | FLL | FLW | NTPH | NPPH | PL | DM | NSP | NFGP | NUGP | GW | BY | HI | TW | GYPH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DF (50%)** | **-0.055** | 0.026 | 0.026 | -0.018 | -0.015 | -0.015 | 0.006 | -0.059 | -0.023 | -0.023 | -0.014 | -0.014 | -0.023 | 0.031 | 0.023 | -0.107 |
| **PH** | -0.001 | **0.001** | 0.001 | 0.000 | -0.001 | -0.001 | 0.000 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | 0.000 | 0.000 | 0.001 | 0.205* |
| **FLL** | 0.020 | -0.037 | **-0.043** | 0.007 | 0.022 | 0.025 | -0.008 | 0.020 | 0.022 | 0.022 | 0.022 | 0.013 | 0.005 | -0.013 | -0.009 | 0.121 |
| **FLW** | 0.014 | -0.008 | -0.007 | **0.043** | 0.015 | 0.015 | -0.006 | 0.015 | 0.025 | 0.025 | 0.018 | 0.026 | 0.013 | 0.004 | -0.010 | 0.282** |
| **NTPH** | -0.029 | 0.053 | 0.054 | -0.037 | **-0.104** | -0.103 | 0.021 | -0.028 | -0.078 | -0.080 | -0.050 | -0.067 | -0.061 | 0.003 | 0.036 | 0.399** |
| **NPPH** | 0.018 | -0.035 | -0.039 | 0.023 | 0.067 | **0.067** | -0.006 | 0.017 | 0.051 | 0.053 | 0.029 | 0.044 | 0.041 | -0.005 | -0.025 | 0.390** |
| **PL** | 0.001 | -0.002 | -0.001 | 0.001 | 0.001 | 0.001 | **-0.006** | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | -0.002 | 0.046 |
| **DM** | -0.043 | 0.019 | 0.019 | -0.014 | -0.011 | -0.010 | 0.003 | **-0.040** | -0.017 | -0.017 | -0.011 | -0.009 | -0.017 | 0.024 | 0.017 | -0.133 |
| **NSP** | 0.118 | -0.139 | -0.142 | 0.165 | 0.209 | 0.213 | -0.046 | 0.119 | **0.279** | 0.278 | 0.191 | 0.227 | 0.132 | -0.001 | -0.130 | 0.334** |
| **NFGP** | -0.118 | 0.139 | 0.139 | -0.160 | -0.216 | -0.222 | 0.043 | -0.120 | -0.279 | **-0.280** | -0.173 | -0.225 | -0.140 | 0.003 | 0.144 | 0.347** |
| **NUGP** | 0.002 | -0.004 | -0.005 | 0.004 | 0.004 | 0.004 | -0.002 | 0.002 | 0.006 | 0.005 | **0.009** | 0.005 | 0.001 | -0.001 | 0.001 | 0.041 |
| **GW** | -0.015 | 0.021 | 0.017 | -0.036 | -0.038 | -0.039 | 0.009 | -0.014 | -0.049 | -0.048 | -0.035 | **-0.060** | -0.038 | -0.022 | 0.014 | 0.699** |
| **BY** | 0.344 | -0.016 | -0.088 | 0.241 | 0.475 | 0.496 | 0.056 | 0.343 | 0.383 | 0.403 | 0.122 | 0.507 | **0.807** | 0.000 | -0.152 | 0.726** |
| **HI** | -0.378 | 0.198 | 0.196 | 0.057 | -0.021 | -0.051 | -0.009 | -0.402 | -0.002 | -0.007 | -0.065 | 0.244 | 0.000 | **0.663** | 0.060 | 0.684** |
| **TW** | 0.014 | -0.011 | -0.007 | 0.007 | 0.011 | 0.012 | -0.009 | 0.014 | 0.015 | 0.017 | -0.003 | 0.008 | 0.006 | -0.003 | **-0.033** | -0.065 |

*DF: Days to 50%flowring, DM: Days to maturity, FL: Flag leaf length (cm), FW: Flag leaf width, PH: Plant height, TT: No. of total tillers per hill, ET: No of effective tillers per hill, PL: Panicle length, NGPP: No of grains per hill, NFGPP: No of filled grains per panicle, NUGPP: No of unfilled grains per panicle, BYP: Biological yield per panicle, TW: Test weight, HI: Harvest index, GYPP: Grain yield per plant*

Grain yield per hill showed the positive significant genotypic association with plant height (0.205*), flag leaf width (0.282**), number of tillers per hill (0.399**), number of panicles per hill (0.390**), number of spikelets per panicle (0.334**), number of filled grains per panicles (0.347**), grain weight (0.699**), biological yield (0.726**), harvest index (0.684**). The correlation of flag leaf length (0.121), panicle length (0.046), number of unfilled grains per panicles (0.041) showed positive non-significant association. The correlation does not show negative significant association. The correlation of days to 50% flowering (-0.107), days to maturity (-0.133), test weight (-0.065) showed negative non-significant association. Similar results are reported by Dinesh et al. [15], Shiva et al. [16], Abdul et al. [12], for test weight harvest index, number of spikelets / panicle and Abdul et al. [12], for biological yield, number of tillers per hill. The positive correlation of grain yield with various traits like plant height, number of tillers per hill, spikelets per panicle, biological yield was supported by Fiyaz et al. [2]. The path analysis at phenotypic level showed positive direct effect of plant height (0.032), flag leaf width (0.031), number of panicles per hill (0.006), number of filled grains per panicle (0.005), grain weight per panicle (0.034), biological yield (0.730), harvest index (0.627), with grain yield per hill. Negative direct effects were exhibited by days to 50% flowering (-0.045), flag leaf length (-0.039), number of tillers per hill (-0.001), panicle length (-0.006), days to maturity (-0.023), number of spikelets per panicle (-0.037), number of unfilled grains per panicle (-0.004), test weight (-0.018), with grain yield per hill. Similar results were reported earlier by Fiyaz et al. [9] for spikelet's per panicle, biological yield per hill, harvest index, test weight, Rashmi et al. [10] for days to maturity, Aditya et al. [13] for days to 50% maturity, plant height, flag leaf width, panicle length, days to maturity, test weight and Kishore et al. [16] for plant height, flag leaf length.

The path analysis at genotypic level showed positive direct effect on biological yield (0.807), harvest index (0.663), number of spikelets per panicle (0.279), number of panicles per hill (0.067), flag leaf width (0.043), number of unfilled grains per panicle (0.009), plant height (0.001) with grain yield per hill. Negative direct effect on grain yield per plant showed for number of filled grains per panicle (- 0.280), number of tillers per hill (-0.104), grain weight (-0.060), days to 50% flowering (-0.055), flag leaf length (-0.043), days to maturity (-0.040), test weight (-0.033), panicle length (-0.006), number of unfilled grains per panicle (-0.009). Similar results were reported earlier by Fiyaz *et al.* (2011) for plant height, number of tillers per hill, panicle length, biological yield per hill, harvest index, test weight, Kishore et al. [16] for plant height, panicle length and Kamana et al. (2019) for days to 50% flowering.

## 4. CONCLUSION

The experimental results concluded that TP-29632, followed by TP-30015, TP-29637, SHUATS DHAN-2 and TP- 30025 was superior in grain yield among 37 exotic rice genotypes. IRRI-5 (TP-29632), IRRI-10 (TP-30015) and IRRI-21(TP-29759) recorded early maturity among 37 genotypes. Grain yield per hill was positively and significantly associated with flag leaf width, number of tillers per hill, number of panicles per hill, number of spikelets per panicle, number of filled grains, grain weight, biological yield, harvest index at both genotypic and phenotypic levels. Biological yield, harvest index, number of panicles per hill, plant height, flag leaf width recorded positive direct effect on grain yield per hill at both phenotypic and genotypic levels. These characters may be given due importance during selection, further testing of genotypes is required to confirm the consistency of results.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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