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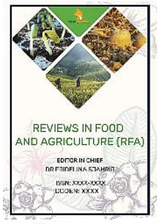

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RESEARCH ARTICLE

CORRELATION AND PATH ANALYSIS OF YIELD AND YIELD ATTRIBUTING CHARACTERS IN RICE UNDER REPRODUCTIVE DROUGHT STRESS CONDITION

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ABSTRACT

A field screening of eight genotypes at farmer's field of Sundarbazar, Lamjung in randomized complete block design with three replications was conducted to study the character association between yield and yield attributing traits of rice and their direct and indirect effect on grain yield under reproductive drought stress condition from June to November 2018. The analysis of variance revealed significant differences for all traits except plant height, which indicates existence of genetic variability, potential for selection and further improvement among all genotypes under study. Correlation and path analysis revealed that flag leaf area, chlorophyll content, days to heading and thousand grain weight showed significant and positive association as well as positive direct effect on yield of rice which means direct selection of these traits would be beneficial for the improvement of grain yield facilitating the selection and progress on breeding program.

KEYWORDS

Correlation, path analysis, rice, drought, stress

1. INTRODUCTION

Rice (*Oryza sativa* L.), a self-pollinating cereal crop, provides food for more than 3.5 billion people worldwide (IRRI, 2017). It is a member of the Graminae family and has the chromosome 2n=24. It is primarily grown in climates that are tropical and subtropical. It is grown in 114 nations, and it provides a living for more than 100 million households in Asia (Kumar et al., 2015). After wheat and maize in terms of worldwide output, rice is the third most produced agricultural product (NGS, 2017). Around the world, 741.4 million tons rice is produced per year (FAOSTAT, 2017). According to Nepal Rashtriya Bank, agriculture provides a livelihood for roughly two-thirds of the country's people and accounts for 28 percent of the country's GDP (NRB, 2019). The agriculture industry is crucial for boosting income, raising the standard of living for Nepalese citizens, and reducing poverty, but it has been struggling since 1995 (K.C. et al., 2021).

Due to the varying climatic circumstances, Nepalese agriculture is diverse, yet it is mostly dominated by three primary cereals: rice, wheat, and maize. Together, these three grains make up 30.92 percent of the country's agricultural GDP and are essential for improving livelihood and ensuring food security (MoAD, 2016). FAOSTAT estimates that Nepal produced 9930178 tonnes of cereal overall in 2018 and that 3428987 hectares were used for cereal agriculture (FAOSTAT, 2018). About 40% of the food calories consumed by Nepalese citizens come from rice, which accounts for about 20% of the agricultural gross domestic product (AGDP) and nearly 7% of the country's overall gross domestic product (GDP) (CDD, 2015). Nepal used to export food up until the middle of the 1980s. Following then, it has progressively turned into a net importer of food (K.C. et al., 2021). Between 2009 and 2013, imports of cereals significantly rose, with annual trend growth rates of 126 percent for wheat, 26 percent for maize, and 39 percent for rice (Thapa et al., 2019). Nepal ranks 72nd out of 195 countries in the Global Hunger Index with 22 points (Grebmer et al., 2017).

The domestic rice production has recently fallen, indicating that it is not enough to meet domestic demand. In Nepal, irrigated rice makes about 56% of the entire rice acreage. Thus, cultivation of rice still occurs under rainfed condition. Abiotic stresses, in particular drought and flooding, are significant yield-limiting variables in regions where rice is grown using rainwater. These have increased in frequency in recent years as a result of changes in the pattern of rainfall. In Nepal, the drought-affected area is projected to be 0.52 million acres. In order to meet the increasing demand of food grain for the ever-increasing population of Nepal, it is essential to develop competent rice varieties with high grain yield under reproductive stage drought stress. The creation of rice cultivars with increased drought resistance that rely on rainfed agriculture is necessary to boost productivity, lower risk, and alleviate poverty in local populations. The identification of parents with different responses to stress is the first stage in creating high-yielding drought-tolerant cultivars.

The donor should be drought tolerant with a moderate to high yield under stress, while the recipient should typically be high yielding under non-stress conditions. The resulting segregant would be able to function well in both low-stress and high-stress situations as a result. Such genotypes must be phenotypically screened under stressful circumstances in order to be identified. There is huge need and scope for combining drought tolerance with high yield potential under favorable conditions to increase the productivity of rice with available resources (Tripathi et al., 2019). The degree of the association between grain yield and its constituent parts is established using correlation and path analysis, which also highlight the

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relative importance of their direct and indirect impacts and provide a clear knowledge of their relationship with grain yield. In the end, the breeder might use this kind of information to assist him create his selection techniques to increase grain yield. In light of the aforementioned situation, the current investigation's main goal is to research the character relationships in rice genotypes for yield improvement under reproductive drought stress condition.

2. Materials and Methods

2.1 Research Design and Layout of Experiment

In a farmer's field in Sundarbazar, Lamjung, an experimental trial involving 8 genotypes was carried out using a Randomized Complete Block Design (RCBD) with 3 replications from June to November of 2018. Thus, there were 24 total plots, each measuring 1.2 * 2 m^2, with a 50 cm distance between them.

2.2 Genetic Materials

The different rice genotypes used in the research are listed below in Table 1.

Table 1: Different genotypes used in research.

S.N.	Genotypes
1	Bahuguni 1
2	Chinarwa 1
3	Janaki
4	Makwanpur 1
5	Radha 11
6	Sabitri
7	Sukha Dhan 1
8	Tarahara 1

2.3 Nursery Establishment and Management

On the premises of the Lamjung campus quarter, a nursery was prepared. Fine soil was made, and seeds are sown. The source seed was obtained from RARS, Khajura, Banke.

2.4 Main Field Preparation

The tractor-assisted plowing of the experimental plot twice was followed by leveling, puddling, and the removal of weeds, stones, and stubbles. Following field preparation, 33 plots were manually created on the field using tape, pegs, and spades. Bunds were well-maintained and developed.

2.5 Nutrient Management

Six tons per hectare of FYM were applied. According to NARC's recommendation, chemical fertilizer was applied by using urea, MOP, and DAP at a rate of 60:40:30 kg/ha. Full dose of MOP and DAP was applied during basal dose. Half of the urea dose was administered as the basal dose, and the remaining urea dose was administered at 25 DAT and 45 DAT.

2.6 Transplanting

In the main field, 25-day-old seedlings were transplanted at a 20*20 cm spacing. Each hill has two to three seedlings.

2.7 Weed Management

On 25 and 45 DAT, manual hand weeding was performed, followed by urea topdressing.

2.8 Water Management

Rice in the vegetative stage received an adequate amount of water. To create stress at the reproductive stage, a drought condition was created after 30 DAT and continued till harvest.

2.9 Harvesting And Threshing

Harvesting was done from net plot manually with the help of sickle. After harvesting, plants were left in-situ on the field for 4 days for sun drying. Manual threshing was done followed by winnowing. Thus, obtained grains were weighed at 12% moisture content.

2.10 Data Recorded

Data were recorded from the randomly selected 5 plants from all plots neglecting the border plants. Observation on yield and yield related attributes were flag leaf area 60 DAT, chlorophyll content 60DAT, plant height 90DAT, panicle length, thousand grain weight, Days to 50% booting, Days to 50% heading, Days to 50% flowering, Days to 50% maturity, filled grain per panicle, effective tiller per meter square, grain yield (kg/ha) after moisture adjustment at 12% were taken.

2.11 Statical Analysis

Analysis of data was done with the help of Excel, SPSS 16 and R Software.

3. Results and Discussion

3.1 Mean Performance and Analysis of Variance

The analysis of variance revealed significant differences for all traits except plant height, which indicates existence of genetic variability, potential for selection and further improvement among all genotypes under study (Table 1 and table 2). Bahuguni 1 recorded highest grain yield which is 39.60% more than that of local check variety, Sabitri.

Table 2: Analysis of variance of Yield and Yield attributing traits

Genotypes	TGW	PL	ETM	FGP	YLD
Bahuguni 1	26.51 c	24.28 ab	34.84 d	120.4 f	4.9 a
Chinarwa 1	20.33 d	22.17 c	28.99 e	111.5 h	2.86 c
Janaki	31.17 b	25 ab	39.24 b	137.5 c	3.96 b
Makwanpur 1	34 a	26.31 a	59.33 a	183.4 a	3.73 b
Radha 11	28.33 c	24.7 ab	39.06 b	133.23 d	4.23 ab
Sabitri	20.6 d	23.76 bc	30.16 e	117.5 g	3.51 bc
Sukha Dhan 1	32.33 ab	25.78 ab	39.93 b	150.9 b	3.67 bc
Tarahara 1	27.67 c	24.41 ab	36.75 c	130.9 e	3.9 b
F test	***	**	***	***	**
LSD (5%)	1.85	1.84	1.77	1.84	0.85
CV %	3.84	4.29	2.62	0.77	12.70
Grand Mean	27.61	24.55	38.55	135.66	3.84

Sig. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TGW= thousand grain weight, PL= panicle length, ETM= effective tiller per meter square, FGP= filled grain per panicle, YLD= grain yield (kg/ha)

Table 3: Analysis of variance for agro-morphological characters							
Genotypes	**PH**	**SPAD**	**LA**	**DTB**	**DTH**	**DTF**	**DTM**
Bahuguni 1	104.67 a	34.63 c	33.59 cd	90.66 b	100.33bc	107 b	148.33 d
Chinarwa 1	109.2 a	34.64 c	25.14 e	76 e	82.67 f	109 a	159.33 b
Janaki	127.26 a	36.34 bc	38.96 b	84.67 d	97 d	91 e	178 a
Makwanpur 1	107.01 a	39.22 a	46.32 a	98.33 a	108 a	84 g	148.33 d
Radha 11	124.54 a	36.22 bc	35.41 c	85.67 cd	98.67 cd	102.67 d	175.33 a
Sabitri	98.7 a	34.5 c	33.41 d	84.67 d	89. 33 e	108 ab	154 c
Sukha Dhan 1	112.2 a	37.38 ab	39.34 b	76.33 e	101 bc	87 f	130 e
Tarahara 1	107.48 a	34.82 c	34.22 cd	88 bc	102.67 b	105.22 c	146 d
F test	Ns	***	***	***	***	***	***
LSD (5%)	-	1.85	1.79	3.17	2.55	1.39	3.19
CV %	15.83	2.94	2.87	2.11	1.49	0.8	1.17
Grand Mean	111	35.97	35.79	85.54	97.4	99.23	154.4

Sig. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

PH= plant height 90DAT, SPAD= chlorophyll content 60DAT, LA= flag leaf area 60 DAT, DTB= Days to 50% booting, DTH= Days to 50% heading, DTF= Days to 50% flowering, DTM= Days to 50% maturity

3.2 Correlation Between Grain Yield and Other Traits

Yield recorded positive as well as significant relationship with flag leaf area (0.92**), chlorophyll content (0.82*), panicle length (0.92**), days to heading (0.88**), effective tillers per meter square (0.8*), filled grain per panicle (0.85**) and thousand grain weight (0.97*). As shown in table 4. Similar results were reported earlier by several workers in rice viz., for the association of grain yield with flag leaf area, filled grains per panicle, chlorophyll content, thousand grain weight, panicle length (Abarshahr et al., 2011; Mukharjee et al., 2018; Abarshahr et al., 2011; Madhavilatha et al., 2005; Abarshahr et al., 2011; Islam et al., 2021). Positive but non-significant relation was obtained between grain yield and plant height and data to booting. Grain yield was negatively and significantly correlated with days to 50% flowering. Same result was found (Kole et al., 2008). While negative and non-significant correlation was obtained between grain yield and days to maturity.

Table 4: Estimation of correlation between grain yield and yield components of eight genotypes of rice at Lamjung, Nepal 2018.											
Traits	**LA**	**SPAD**	**PH**	**PL**	**DTB**	**DTH**	**DTF**	**DTM**	**ETM**	**FGP**	**TGW**	**YLD**
LA	1											
SPAD	0.87**	1										
PH	0.18	0.26	1									
PL	0.95**	0.8*	0.2	1								
DTB	0.6	0.38	-0.17	0.53	1							
DTH	0.83**	0.64	0.11	0.91**	0.68	1						
DTF	-0.87**	-0.93**	-0.33	-0.83*	-0.23	-0.62	1					
DTM	-0.16	-0.15	0.67	-0.27	0.03	-0.3	0.19	1				
ETM	0.89**	0.92**	0.13	0.82*	0.68	0.79*	-0.81*	-0.13	1			
FGP	0.92**	0.96**	0.13	0.85**	0.53	0.77*	-0.9**	-0.25	0.97**	1		
TGW	0.88**	0.84**	0.44	0.92**	0.4	0.86**	-0.89**	-0.14	0.82*	0.86**	1	
YLD	0.92**	0.82*	0.39	0.92**	0.43	0.88**	-0.86**	-0.16	0.8*	0.85**	0.97*	1

*Significant at 0.05 level (2-tailed).

**significant at 0.01 level (2-tailed).

PH= plant height 90DAT, SPAD= chlorophyll content 60DAT, LA= flag leaf area 60 DAT, DTB= Days to 50% booting, DTH= Days to 50% heading, DTF= Days to 50% flowering, DTM= Days to 50% maturity, TGW= thousand grain weight, PL= panicle length, ETM= effective tiller per meter square, FGP= filled grain per panicle, YLD= grain yield (kg/ha)

3.3 Path Coefficient Analysis

Direct as well as indirect effect of all the traits recorded on grain yield has been presented (Table 5). Direct positive effect on yield of rice genotypes was shown by trait thousand grain weight (0.86), flag leaf area (0.71), days to flowering (0.67), chlorophyll content (0.52) and days to heading (0.01). Similar results were reported for thousand grain weight, flag leaf area and chlorophyll content (Shrestha et al., 2018). Strong negative direct effect was shown by effective tillers per meter square (-0.41) followed by days to booting (-0.13). In terms of indirect effect, strongest positive indirect effect was shown by flag leaf area (0.76), filled grains per panicle (0.73), days to heading (0.72), panicle length (0.72), effective tillers per meter square (0.71), chlorophyll content (0.69) via thousand grain weight, filled grains per panicle (0.65), effective tillers per meter square (0.63), thousand grain weight (0.63) via flag leaf area. Strong negative indirect effect was demonstrated by days to flowering via thousand grain weight (-0.74) followed by days to flowering via flag leaf area (-0.61), filled grains per panicle via days to flowering (-0.59).

Table 5: Path analysis (Direct and indirect effects) of yield components on grain yield.

Traits	LA	SPAD	PH	PL	DTB	DTH	DTF	DTM	ETM	FGP	TGW
LA	0.71	0.59	0.09	0.6	0.4	0.57	-0.61	-0.11	0.63	0.65	0.63
SPAD	0.44	0.52	0.13	0.44	0.16	0.29	-0.42	-0.06	0.45	0.46	0.42
PH	-0.005	-0.01	-0.04	-0.01	0.004	-0.001	0.007	-0.01	-0.004	-0.003	-0.01
PL	-0.02	-0.02	-0.007	-0.03	-0.01	-0.02	0.02	0.007	-0.02	-0.02	-0.02
DTB	-0.07	-0.04	0.014	-0.05	-0.13	-0.08	0.02	-0.005	-0.08	-0.06	-0.05
DTH	0.008	0.005	0.0004	0.007	0.006	0.01	-0.006	-0.003	0.007	0.007	0.008
DTF	-0.57	-0.53	-0.11	-0.43	-0.15	-0.41	0.67	0.12	-0.53	-0.59	-0.57
DTM	0.001	0.001	-0.002	0.001	-0.0003	0.002	-0.001	-0.007	0.001	0.002	0.001
ETM	-0.36	-0.35	-0.04	-0.29	-0.27	-0.31	0.33	0.05	-0.41	-0.39	-0.33
FGP	-0.003	-0.003	-0.0003	-0.003	-0.001	-0.002	0.003	0.0009	-0.003	-0.003	-0.003
TGW	0.76	0.69	0.24	0.72	0.32	0.72	-0.74	-0.11	0.71	0.73	0.86

PH= plant height 90DAT, SPAD= chlorophyll content 60DAT, LA= flag leaf area 60 DAT, DTB= Days to 50% booting, DTH= Days to 50% heading, DTF= Days to 50% flowering, DTM= Days to 50% maturity, TGW= thousand grain weight, PL= panicle length, ETM= effective tiller per meter square, FGP= filled grain per panicle, YLD= grain yield (kg/ha)

4. Conclusion

Results revealed significant differences for all traits except plant height, which indicates existence of genetic variability, potential for selection and further improvement among all genotypes under study. It had been found that flag leaf area, chlorophyll content, days to heading and thousand grain weight showed significant and positive association as well as positive direct effect on yield of rice which means direct selection of these traits would be beneficial for the rice varieties improvement regarding their yield.

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