The Pharma Innovation Journal 2022; 11(4): 984-988

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(4): 984-988

www.thepharmajournal.com
Received: 16-01-2022
Accepted: 22-03-2022

Neha Chakrawarti
Department of Plant Breeding and Genetics, AAU, Jorhat, Assam, India

Rupam Borgohain
Department of Plant Breeding and Genetics, AAU, Jorhat, Assam, India

Thirangtha Brahma
Department of Plant Breeding and Genetics, AAU, Jorhat, Assam, India

Rajshree Verma
Department of Plant Pathology, AAU, Jorhat, Assam, India

Corresponding Author:
Neha Chakrawarti
Department of Plant Breeding and Genetics, AAU, Jorhat, Assam, India

Study of Inter-relationships among traits related to ratooning ability and perennation and yield in rice genotypes of Assam

Neha Chakrawarti, Rupam Borgohain, Thirangtha Brahma and Rajshree Verma

Abstract
A field research was carried out taking 50 rice genotypes collected from different regions of Assam with respect to ratooning ability and perennation. Inter-relationship of some main crop traits to that of ratooning ability and perennation was studied. Path Coefficient analysis was carried out to dissect the direct and indirect effects of main crop traits to ratooning ability and ratoon yield of the genotypes. Ratooning ability was found to be significant and positively associated with four main crop traits namely, tiller wall thickness (0.74), greenness of leaves at maturity (0.64), tiller diameter (0.37) and tiller weight (0.34). It was negatively correlated with plant height and harvest index of the main crop. In ratoon crop all observed traits except ratoon plant height, number of lodging tillers and number of dwarf tiller exhibited significant positive correlation with ratoon yield per plant. Genotypic path coefficient analysis indicated that tiller wall thickness (0.59) and tiller weight (0.47) of the main crop had highest positive direct effect on ratooning ability among all the main crop traits suggesting that these traits were essential for better ratooning ability while plant height and harvest index had negative direct effects. In ratoon crop, number of productive ratoon tiller had highest positive direct effect (4.36) on ratoon yield suggesting that during the breeding programme for enhancing ratoon yield, more emphasis should be given on enhancing number of productive ratoon tillers.

Keywords: Rice, ratooning ability, correlation studies, path coefficient analysis, yield components, perennation

Introduction
Rice is considered as one of the major component of daily diet for 3.5 billion people around the globe. In India, the production of 121 million tones of rice was recorded for year 2021. The present production level is only able to meet the current demand. However, to feed the ever increasing population we need to enhance the production upto 130 million tonnes by 2025. In order to fulfill this target, several factors need to be considered. Present day rice varieties have annual life cycle. Albeit, annual type varieties are not the best choice for some agricultural situations. For example in hilly, shifting cultivation is the normal cultivation practice. Such practices often lead to various level of soil erosion and reduction in available soil nutrient content. To overcome this problem, perennial rice can be an effective solution. Cultivating a self perpituating rice crop in these ecosystems shall protect the top soils from the erosive and leaching actions of water and wind by providing year-round crop cover. It will also reduce mechanical field operations as the soil will not be reworked each year. Input and production costs like seed, planting and labour will be reduced as planting will be done every 3-4 years only. Ratooning ability of a crop is the reflection of its perennial nature. Ratooning ability can be defined as the ability or potential of a plant to regenerate from the remaining stubbles. It is the stored energy in the stubbles which is transformed into the new plant growth. Ling *et al.* 2019 and Wang *et al.* 2020 [4, 14] has defined ratooning as the resource efficient green technology. The genetic constitution of these regrowth are similar to mother plant. Thus ratooning is the kind of an asexual propogation. Perennation in *O. sativa* is by growth of axillary buds on older tillers (i.e. tillering), whereas *O. rufipogon* can additionally propagate from stolons, and *O. longistaminata* produces many long rhizomes that are the primary source of new shoots. Additional yield from rhizome and stolon can also help farmer to stabilize and diversify mixed crop-livestock systems in marginal environments.

For selecting the cultivar with ratooning ability, it is necessary and foremost step to find those main crop traits which are associated with good ratooning ability. It is worth mentioning that not all the cultivars having ratooning ability leads to ratoon grain yield. Due to this reason, we also need to find out ratoon crop traits association with ratoon grain yield. The present research is therefore aimed at finding out those main crop traits which are associated with ratooning ability and also those ratoon crop traits which are correlated with ratoon grain yield. However the correlation studies shows only degree and direction of association which is not completely reliable. Therefore, for more clear picture of trait association, Path coefficient analysis was also carried out to find direct and indirect effect of various correlated traits.

Material and Method

The research was carried out in ICR farm of AAU, Jorhat (Assam) in 2021-2022. 50 rice cultivars from collected from RARS Diphu, RARS Lakhimpur, RARS Karimganj and IARI were used as experimental material. These 50 genotypes also includes two wild species *O. longistaminata* and *O. rufipogon*. Randomized complete block design was followed. All the measures of an ideal package of practices for were taken. Harvesting was done when the crop achieved 95% maturity. The plant were cut at at height of 15 cm as per suggested by Santose *et al*. 2003 [9]. One day after harvesting, additional amount of fertilizers were applied to enhance the ratoon growth. Phenotypic evaluation was done for main crop and for ratoon crop. Five plants from each treatment were randomly chosen for evaluation. In main crop 11 morphological characters *viz*, Number of tillers, Number of effective tillers, Tiller diameter(cm),Tiller wall thickness (mm),Tiller weight (g), Plant height (cm), Green seeker reading/Leaf greenness at maturity, Yield per tiller(g), Yield per plant(g),Number of filled grains, Harvest index (%) and in ratoon crop 11 traits viz. Number of ratoon tillers, Number of productive ratoon tillers, Number of lodging tillers, Number of dwarf tillers, Ratoon plant height (cm), Days to ratoon maturity, Ratoon spikelet fertility (%), Yield per ratoon tiller (g), Yield per ratoon plant (g), Days to ratoon origin/emergence, Number of nodal tillers, Number of basal tillers were observed.

The genotypic and phenotypic correlation coefficients between any two traits say X and Y under study were calculated. For this calculation, variance and covariance analysis of data was done and the respective correlation coefficients were computed using the formula given by Choudhary and Singh (1979) [11]. Path Coefficient analysis is a simple standardized partial regression coefficient method to detect direct and indirect effects of independent variables on the dependent variable. This analysis helps to separate each correlation coefficient into components of direct and indirect effects and was calculated using the formula suggested by Wright (1921) [15] and Dewey and Lu (1959).

Result and Discussion

For all the analysis in ratoon crop, out of 50 genotypes only those genotypes were considered which produced ratoon yield or productive ratoon tillers. There were 30 such genotypes which produced ratoon yield. Hence only these 30 genotypes were considered for correlation and path coefficient analysis.

Correlation between ratooning ability and main crop traits

The genotypic correlation studies for ratooning ability (number of productive ratoon tillers) and main crop traits revealed (Table 1a) the highest positive association of number of ratoon productive tillers was found with tiller wall thickness (0.742) followed by green seeker reading (0.646) followed by tiller diameter (0.376) at both 5% and 1% level of significance. However the trait exhibited negative correlation with plant height (-0.253) and harvest index (-.241) of the main crop at 5% level of significance showing their negative impact on number rationing ability. Other traits namely number of tillers, number of effective tillers, yield per tiller, yield per plant and number of filled grains of the main crop had no significant correlation with ratooning ability.

The result of positive correlation between tiller wall thickness and ratooning ability was justified by Vergara *et al.* 1988 [13] who concluded that culm of the rice plant is the main storage organ and thick culm has potential to store more carbohydrate which is reflected in form of good ratoon potential. The observation by Ichii *et al.* (1983) [2] and Samson (1980) [8] also supported the current result. A positive correlation between tiller weight of the main crop and ratooning ability in rice was also observed by Shong (1998) [10]. He also stated that by increasing the percentage of green leaves after heading of the first season rice may increase dry matter production which will reflect in form of potential of a genotype to regenerate from stubbles. The extent of greenness of flag leaf at maturity in main crop indicates the continuous production and supply of energy to the whole plant system. This source of energy gives regeneration potential to the plant which is expressed in terms of production of ratoon tillers.

A negative correlation of ratooning ability was observed with plant height and harvest index of the main crop. A similar result for negative correlation of harvest index with ratooning ability was also found by Shong (1998) [10] who observed that with increase in harvest index the length of ratooning bud decreases. This was indirectly supported from the study of Tianju *et al.*(2006) [12] who found a negative correlation between grain yield per panicle and grain weight per panicle in main crop with ratooning ability which are main components contributing towards high harvest index. They have also scored a negative correlation between main crop plant height and ratooning ability. Zhang *et al.* (2012) [16] proposed that short statured rice varieties with lower harvest index as the main character for high regeneration capacity. Similar results were also observed in the present studies as cultivars like Binadhan-11, Sayjihari, IR-64 etc. were all short stature with low to medium harvest index and possessed better ratooning ability.

Almost similar result was also observed in the phenotypic correlation studies except for the fact that phenotypic correlation of harvest index with ratooning ability was nonsignificant as compared to that of genotypic correlations suggesting that the significant negative correlation of this trait with ratooning ability in case of latter may be due to involvement of a significant GxE interactions.

Correlation between yield and yield components in ratoon crop

In the present investigation, several traits of the ratoon crop were found to be positively correlated (Table 1b) with ratoon yield. At both genotypic and phenotypic level traits namely number of ratoon tillers/hill, number of productive ratoon tillers/hill, number of dwarf tillers/hill, days to ratoon maturity, ratoon spikelet fertility, yield per ratoon tiller, days to ratoon emergence, number of nodal tillers and number of basal tillers had significant positive correlation with yield per ratoon plant. The maximum positive correlation was shown with number of productive ratoon tiller (0.847) followed by number of ratoon tillers (0.846) followed by days to ratoon maturity (0.760) at both 5% and 1% level of significance.

This result is supported by Nair *et al*. (2006) [6] who observed high positive correlation of ratoon yield with number of tillers and number of productive ratoon tillers. A similar result was also observed by Prakash and Prakash (1987) [7]. Ratoon spikelet fertility was found to be positively correlated with number of ratoon tillers/hill, days to ratoon emergence, number of productive ratoon tillers, days to ratoon maturity and number of basal tillers. Such correlation was also found by Faruq *et al*. (2014) [1].

A significant positive correlation of number of productive ratoon tillers was observed with maximum number of yield component. Faruq *et al.* (2014) [1] also obtained similar result and concluded that number of productive ratoon tillers is the most essential trait for higher grain yield in the ratoon crop.

Positive correlation of ratoon yield was observed with number of nodal tillers and number of basal tillers. Basal tillers are those tillers which were regenerated from lower most nodes (nodes present inside the soil) while nodal tillers are those which originated from upper nodes. It was noteworthy to mention that the value of correlation of ratoon yield was higher with number of basal tillers as compared to that of number of nodal tillers. Such result can be explained from research conducted by Iso (1954) [3] who proposed that tillers originate from upper nodes have high C:N ratio which reacted like old seedlings whereas tillers originate from the base have low C:N ratio which have the characteristics of young seedlings due to which their productive performance was better. Therefore, development of greater number of lower tiller should produce more yield in ratoon crop.

Simple correlation does not provide a clear picture of contribution of all the characters towards a particular trait. Correlation coefficient values shows association between different characters while path analysis splits the interrelationship values into direct and indirect effects. Path coefficient analysis was developed by Wright (1921) [15] and the analysis provides a potential means for resolving direct and indirect cases of association and allows an effective evaluation of particular forces acting to produce a given interrelationship**.**

Path coefficient analysis for direct and indirect effect of main crop traits on ratooning ability

The result from path analysis revealed that (Table 2a) the main crop traits namely Tiller wall thickness, tiller weight, number of tillers, number of effective tillers, yield per plant and green seeker reading showed high to moderate positive direct effect on rationing ability with the values 0.593,0.476,0.450, 0.322,0.249 and 0.242 respectively. Trait yield per tiller had low positive direct effect (0.163) while the traits viz. harvest index, tiller diameter, plant height and number of filled grains showed moderate to low negative direct effect with the values -0.394 -0.252, -0.207 and -0.075 respectively. The indirect effect of main crop number of tillers on ratooning ability via yield per tiller was found moderate with the value of 0.214 while indirect effect of this trait through harvest index was found low with the value of 0.108

Tiller wall thickness exhibited highest positive direct effect on ratooning ability. This trait also exhibited a significant positive correlation with ratooning ability suggesting that the direct selection of this trait will be effective for improving ratooning ability and provides a true relationship of this trait with ratooning ability. Similar result was also found for tiller weight. Tianju *et al*. (2006) [12] also found a high positive direct effect of tiller weight on ratooning ability with positive correlation between both the traits. Leaf greenness at maturity (Green seeker reading) had a moderate direct effect on ratooning ability with a significant positive correlation. This result indicated that genotypes having greater number of green leaves (including the flag leaf) at crop maturity stage may be better in their ratooning ability as these genotypes remain photo synthetically active even in maturity stage. Therefore, selection for leaf greenness at maturity may be a good selection index for good ratooning ability. Tiller diameter exhibited negative direct effect on ratooning ability but had a significant positive correlation due to the positive indirect effect via tiller wall thickness and tiller weight. As the direct effect was negative, the direct selection of tiller diameter will be ineffective in improving ratooning ability. However, by selecting higher tiller wall thickness and higher tiller weight the negative direct effect of tiller diameter can be compensated.

The direct effect of number of tillers and number of effective tillers in main crop was high but correlation of both the traits with ratooning ability was non-significant. Similarly, the direct effect of yield per tiller and yield per plant in main crop on ratooning ability was moderate but the correlation of both the traits was non-significant with ratoon yield per plant. Liu *et al*. (2019) [5] also found hight positive direct effect of number of effective tillers in main crop on ratooning ability.

The direct effect of plant height in main crop was negative and its correlation with ratooning ability was also negative. A similar result was also obtained for harvest index suggesting the negative impact of these traits on regeneration potential.

The residual effect in this path analysis was 0.11 which suggested that the 11 main crop traits under present investigation were contributing for 89% of total variability towards the ratooning ability

Path analysis for direct and indirect effect of ratoon crop traits on ratoon yield

The results from path analysis revealed that (Table 2b) the traits namely ratoon productive tiller, yield per ratoon tiller and number of dwarf tiller showed very high to high positive direct effect on yield per ratoon plant with the values 4.63, 0.87 and 0.43 respectively. While the traits namely number of ratoon tillers, number of lodged tillers, ratoon plant height, days to ratoon maturity, number of nodal tiller and number of basal tiller had direct negative effect on the ratoon yield with the values and -2.22, -0.26, -0.25, -1.2, -0.76 and -0.23 respectively. However, days to ratoon emergence and ratoon spikelet fertility exhibited moderate to low positive direct effects of ratoon yield per plant. Out of all the above characters, number of ratoon tiller had the highest direct negative effect on ratoon yield per plant which was in contrast to the correlation results where number of ratoon tiller had high positive correlation with ratoon grain yield per plant. High negative direct effect of a trait might be nullified by its positive indirect effects through other independent traits. In this case, the high negative direct effect of number of ratoon tiller might have been compensated by its high positive indirect effect on yield per ratoon plant through number of productive ratoon tiller.

Among all the traits, number of productive tiller/hill had the highest positive direct effect on grain yield coupled with significant positive correlation value which indicated that selection of genotypes producing high number of productive tillers in ratoon crop would enhance the ratoon grain yield per plant.

Though ratoon spikelet fertility exhibited very low positive direct effect on ratoon yield, but its correlation was significantly high with yield per ratoon plant. However, ratoon spikelet fertility had high positive indirect effect through number of productive ratoon tiller which suggests that ratoon yield can be improved indirectly by enhancing ratoon spikelet fertility through number of productive ratoon tiller. Ratoon spikelet fertility also showed high negative indirect effect on ratoon yield through number of tiller.

Days to ratoon emergence exhibited negative direct effect on grain yield/plant coupled with high positive correlation. However, the trait had positive indirect effect on ratoon grain yield through number of productive ratoon tillers and negative indirect effect through number of ratoon tillers.

Number of basal tillers and number of nodal tillers showed negative direct effect on ratoon yield per plant along with high significant positive correlation. Number of basal tillers and number of nodal tillers exhibited high positive indirect effect on ratoon yield through number of productive ratoon tiller and negative indirect effect through number of ratoon tiller.

Ratoon plant height exhibited negative direct effect as well as non-significant association with yield per ratoon plant which indicated that ratoon plant height may not play a major role in improving grain yield in the ratoon crop.

Table 1a: Genotypic (below diagonal) and phenotypic (above diagonal) correlation coefficient between ratooning ability and main crop traits

	NNT	NET	TTD	TTWT	TTW	PPH	GGS	YYPT	YYPP	NNFG	HHI	NNRPT
NNT		00.821**	--0.203^{NS}	--0.109^{NS}	--0.428**	--0.112^{NS}	--0.188^{NS}	--0.423**	00.002^{NS}	--0.307**	--0.010^{NS}	00.161^{NS}
NNET	00.791**		--0.216*	--0.103^{NS}	--0.366**	00.092^{NS}	--0.239*	--0.469**	00.028^{NS}	--0.256*	00.003^{NS}	00.063^{NS}
TTD	--0.327**	--0.340**		00.538**	00.662**	00.031^{NS}	00.472**	00.071^{NS}	--0.162^{NS}	00.259*	--0.214*	00.338**
TTWT	--0.245*	--0.279**	00.664**		00.478**	--0.222*	00.511**	00.092^{NS}	--0.014^{NS}	--0.003^{NS}	--0.115^{NS}	00.529**
TTW	--0.657**	--0.600**	00.697**	00.564**		00.329**	00.528**	00.369**	--0.054^{NS}	00.416**	--0.224*	00.305**
PPH	--0.248*	--0.014^{NS}	00.026^{NS}	--0.278**	00.344**		--0.129^{NS}	00.286**	00.043^{NS}	00.598**	--0.208*	--0.217*
GGS	--0.258*	--0.379**	00.603**	00.692**	00.667**	--0.171^{NS}		00.057^{NS}	--0.052^{NS}	--0.062^{NS}	--0.073^{NS}	00.452**
YYPT	--0.605**	--0.655**	00.068^{NS}	00.098^{NS}	00.462**	00.400**	00.110^{NS}		00.422**	00.491**	00.199^{NS}	--0.044^{NS}
YYPP	--0.196^{NS}	--0.169^{NS}	--0.537**	--0.275**	--0.191^{NS}	00.006^{NS}	-0.050^{NS}	00.814**		00.100^{NS}	00.579**	--0.059^{NS}
NNFG	--0.499**	--0.316**	00.283**	00.055^{NS}	00.487**	00.820**	--0.021^{NS}	00.613**	00.168^{NS}		--0.070^{NS}	--0.108^{NS}
HHI	00.040^{NS}	00.109^{NS}	--0.415**	--0.203^{NS}	--0.301**	--0.288**	-0.064^{NS}	00.298**	00.620**	--0.148^{NS}		--0.156^{NS}
NNRPT	00.193^{NS}	00.056^{NS}	00.376**	00.742**	0.345**	--0.253*	00.646**	--0.077^{NS}	--0.149^{NS}	--0.183^{NS}	--0.241*	

*Significant at 5% level of significance **Significant at 1% level of significance

NT - Number of tillers, NET - Number of effective tillers, TD - Tiller diameter (cm), TWT - Tiller wall thickness (mm), TW - Tiller weight (g), PH - Plant height (cm), GS - Green seeker reading, YPT - Yield per tiller (g), YPP - Yield per plant (g), NFG - number of fertile grain, HI - Harvest index, NRPT - Number of ratoon productive tillers

Table 1b: Genotypic (below diagonal) and phenotypic (above diagonal) correlation coefficient between yield and yield components in ratoon crop

	NNRT	NNRPT	NNLT	NDT	RPH	DRM	RSF	RYPRT	RYPRP	DDRO	NNT	BBT
NNRT		00.971**	--0.244*	00.225*	--0.040^{NS}	00.481**	00.467**	--0.158^{NS}	00.791**	00.324**	00.694**	00.681**
NNRPT	00.982**		--0.232*	00.146^{NS}	--0.034^{NS}	00.529**	00.477**	--0.182^{NS}	00.806**	00.318**	00.638**	00.685**
NNLT	--0.323**	--0.326**		00.067^{NS}	00.454**	--0.176^{NS}	0.0112^{NS}	00.282**	--0.060^{NS}	--0.172^{NS}	--0.227*	-0.187NS
NNDT	00.220*	00.141^{NS}	00.081^{NS}		00.088^{NS}	00.067^{NS}	--0.054^{NS}	00.046^{NS}	00.208*	--0.184^{NS}	00.217*	00.103NS
RRPH	--0.054^{NS}	--0.045^{NS}	00.523**	00.097^{NS}		--0.010^{NS}	--0.096^{NS}	00.344**	00.077^{NS}	--0.301**	--0.076NS	--0.139NS
DDRM	00.758**	00.812**	--0.261*	00.132^{NS}	--0.073^{NS}		00.405**	--0.028^{NS}	00.490**	00.208*	00.105NS	00.469**
R RSF	00.511**	00.510**	00.125^{NS}	--0.046^{NS}	--0.108^{NS}	00.541**		00.413**	00.674**	00.648**	00.158NS	00.336**
RYPRT	--0.167^{NS}	--0.221*	00.281**	00.063^{NS}	00.409**	--0.020^{NS}	00.557**		00.332**	00.023^{NS}	--0.230*	--0.124NS
PYPRP	00.846**	00.847**	--0.068^{NS}	00.225*	00.079^{NS}	00.760**	00.704**	00.271**		00.416**	00.387**	00.604**
DDRO	00.342**	00.336**	--0.190^{NS}	--0.198^{NS}	--0.309**	00.347**	00.706**	00.049^{NS}	00.455**		00.159NS	0.166NS
NNT	00.667**	00.627**	--0.322**	00.213*	--0.109NS	00.182NS	00.189NS	--0.251*	00.428**	00.177^{NS}		0.078NS
BBT	00.713**	00.720**	--0.238*	00.109NS	--0.144NS	00.710**	00.357**	--0.153NS	00.634**	00.170^{NS}	00.096NS	

*Significant at 5% level of significance **Significant at 1% level of significance

NRT - Number of ratoon tillers, NRPT - Number of ratoon productive tillers, NLT - Number of lodging tillers, NDT - Number of dwarf tillers, RPH - Ratoon plant height, DRM - Days to ratoon maturity, RSF - Ratoon spikelet fertility, YPRT - Yield per ratoon tiller (g), YPRP - Ratoon yield per plant (g), DRO - Days to ratoon origin, NT - Number of nodal tillers, BT - Number of basal tillers

Table 2a: Path coefficient analysis for direct (bold) and indirect effect of main crop traits on ratooning ability

Trait	NNT	NNET	TTD	TTWT	TTW	PPH	GGS	YYPT	YYPP	NNFG	HHI	Total = r (NRPT)
NNT	00.450	00.254	00.083	--0.145	--0.313	00.051	--0.062	--0.099	--0.049	00.037	--0.016	00.193
NNET	00.356	00.322	00.086	--0.165	--0.285	00.003	--0.092	--0.107	--0.042	00.024	--0.043	00.056
TTD	--0.147	--0.110	--0.252	00.394	00.331	--0.005	00.146	00.011	--0.134	--0.021	00.163	00.376
TTWT	--0.110	--0.090	--0.167	00.593	00.268	00.058	00.167	00.016	--0.068	--0.004	00.080	00.742
TTW	--0.296	--0.193	--0.176	00.334	00.476	--0.071	00.161	00.075	--0.048	--0.037	00.119	00.345

PPH	--0.112	--0.005	--0.007	--0.165	00.164	--0.207	--0.041	00.065	00.002	--0.062	00.114	--0.253
GGS	--0.116	--0.122	--0.152	00.410	00.317	00.035	00.242	00.018	--0.012	00.002	00.025	00.646
YYPT	--0.272	--0.211	--0.017	00.058	00.220	--0.083	00.027	00.163	00.203	--0.046	--0.118	--0.077
YYPP	--0.088	--0.054	00.135	--0.163	--0.091	--0.001	--0.012	00.133	00.249	--0.013	--0.244	--0.149
NNFG	--0.225	--0.102	--0.071	00.033	00.231	--0.170	--0.005	00.100	00.042	--0.075	00.059	--0.183
HHI	00.018	00.035	00.105	--0.120	--0.143	00.060	--0.015	00.049	00.154	00.011	--0.394	--0.242

Residual are 0.11851

NT - Number of tillers, NET - Number of effective tillers, TD - Tiller diameter (cm), TWT - Tiller wall thickness (mm), TW - Tiller weight (g), PH - Plant height (cm), GS - Green seeker reading, YPT - Yield per tiller (g), YPP - Yield per plant (g), NFG - number of fertile grain, HI - Harvest index, NRPT - Number of ratoon productive tillers

Table 2b: Path analysis for direct (bold) and indirect effect of ratoon crop traits on ratoon yield

Traits	NNRT	NNRPT	NNLT	NNDT	RRPH	DDRM	RRSF	YYPRT	DDRO	NNT	BBT	Total = r (YPRP)
NNRT	--2.226	44.553	00.087	00.095	00.013	--0.916	00.020	--0.147	00.048	--0.513	--0.168	00.846
NNRPT	--2.187	44.636	00.088	00.061	00.011	--0.982	00.020	--0.195	00.047	--0.482	--0.170	00.847
NNLT	00.719	--1.512	--0.269	00.035	--0.131	00.316	00.005	00.490	--0.027	00.248	00.056	--0.068
NNDT	--0.490	00.653	--0.022	00.431	--0.024	--0.159	--0.002	00.056	--0.028	--0.164	--0.026	00.225
RRPH	00.120	--0.210	--0.140	00.042	--0.250	00.088	--0.004	00.359	--0.043	00.083	00.034	00.079
DDRM	--1.687	33.766	00.070	00.057	00.018	--1.209	00.021	--0.018	00.048	--0.140	--0.167	00.760
RRSF	--1.137	22.366	--0.034	-0.020	00.027	--0.650	00.039	00.247	00.099	--0.145	--0.084	00.704
YYPRT	--1.026	00.371	--0.150	00.027	--0.102	00.024	00.011	00.879	00.007	00.193	00.036	00.271
DDRO	--0.761	11.558	00.051	--0.085	00.077	--0.419	00.027	00.043	00.140	--0.136	--0.040	00.455
NNT	--1.486	22.908	00.087	00.092	00.027	--0.220	00.007	--0.220	00.025	--0.769	--0.023	00.428
BBT	--1.588	33.340	00.064	00.047	00.036	--0.858	00.014	--0.135	00.024	--0.074	--0.235	00.634

Residual are 0.06847

NRT - Number of ratoon tillers, NRPT - Number of ratoon productive tiller, NLT - Number of lodging tillers, NDT - Number of dwarf tillers, RPH - Ratoon plant height, DRM - Days to ratoon maturity, RSF - Ratoon spikelet fertility, YPRT - Yield per ratoon tiller (g), DRO - Days to ratoon origin, NT - Number of nodal tillers, BT - Number of basal tillers

Conclusion

The genotypic correlation studies for ratooning ability (number of productive ratoon tillers) and main crop traits exhibited that traits namely Tiller diameter, tiller wall thickness, tiller weight and flag leaf greenness at maturity had high positive correlation with ratooning ability. So these traits may be used to predict the ratoon performance of the main crop.

An important conclusion that can be drawn from path analysis is that increasing the number of ratoon tillers may not necessarily increase ratoon yield as increasing number of ratoon tillers would not always be coupled with increase in number of productive ratoon tillers which has shown to be an important trait for enhancing ratoon yield. Thus, during the breeding programme for enhancing ratoon yield, more emphasis should be given on enhancing number of productive ratoon tillers rather than number of ratoon tiller alone as every ratoon tiller does not contribute to grain yield in ratoon crop.

References

1. Faruq G, Taha RM, Prodhan ZH. Rice ratoon crop: A sustainable rice production system for tropical hill agriculture. Sustainability. 2014;6(9):5785-5800.
2. Ichii M, Sumi Y. Effect of food reserves on the ratoon growth of rice plant. Japanese Journal of Crop Science. 1983;52(1):15-21
3. Iso E. Ratoon culture of horai varieties. Rice and Crops in its Rotation in Subtropical Zones, Japan - FAO Association, Tokyo, 1954.
4. Ling X, Zhang T, Deng N, Yuan S, Yuan G, He W *et al*. Modelling rice growth and grain yield in rice ratooning production system. Field Crops Research. 2019;241:107574.
5. Liu X, Zhu R, Zhu B, Yang M, Liu Z. Correlation analysis of ratooning ability and yield with its main crop agronomic traits in rice. Journal of Southern Agriculture. 2019;50(12):2688-2694.
6. Nair AS, Rosamma CA. Character association in ratoon crop of rice (*Oryza sativa* L.). Journal of Tropical Agriculture. 2006;40:1-3
7. Prakash S, Prakash BG. Path analysis in ratoon rice. In Rice Abstract. 1987;24:215-218.
8. Samson BT. Rice ratooning: effects of varietal type and some cultural management practices. Unpublished MS thesis, UPLB, Los Banõs, Philippines), 1980.
9. Santos AB, Fageria NK, Prabhu AS. Rice ratooning management practices for higher yields. Communications in soil science and plant analysis. 2003;34(5-6):881-918.
10. Shong, XFXHH. Relationship Between Single Stem Sheath Dry Matter Weight of Main Crop and Ratooning Ability and High Yield Cultivation Approach in Hybrid Mid rice. Southwest China Journal of Agricultural Sciences, 1998.
11. Singh RK, Choudhary BD. Biometrical Methods in Quantitative Genetic Analysis (reviseded.) Kalyani Pub. Ludhiana, New Delhi, 1979.
12. Tianju R, Zhicheng J, Peihua W. Correlation of ratooning ability with its main crop agronomic traits in midseason hybrid rice. Acta Agronomica Sinica, 2006.
13. Vergara BS, Lopez FSS, Chauhan JS. Morphology and physiology of ratoon rice. International Rice Research Institute (Los Baños, Filipinas). Rice ratooning. Los Baños, 1988,31-40
14. Wang W, He A, Jiang G, Sun H, Jiang M, Man J *et al*. Ratoon rice technology: A green and resource-efficient way for rice production. In Advances in Agronomy. 2020;159:135-167.
15. Wright S. Correlation and causation. Journal of Agricultural Research. 1921;20:557-585
16. Zhang L, Xiong H, Xu, F, Zhu Y, Guo X, Zhou X *et al*. Relationship between Living Rate of Bud and Emergence Rate of Ratoon Rice and Characteristics of the First Cropping Mid-Season Hybrid Rice. Agricultural Science and Technology. 2012;13(9):1873.