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Association and Path Coefficint Analysis for Yield and Yield Attributes in Rice (*Oryza sativa* L.)

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Abstract: The experiment was carried out in the instructional farm of the College of Agriculture in Rewa, Madhya Pradesh. The crosses were carried out in a diallel fashion, excluding reciprocal crosses, with 10 parents and 45 hybrids. These were assessed for "Association and Path Coefficient Analysis in Rice (Oryza sativa L.)" in a randomized block design (RBD) with three replications during kharif 2019. The grain yield per plant exhibited a highly significant positive phenotypic correlation with biological yield per plant, followed by panicle weight, number of filled grains per panicle, number of effective tillers per plant, total tillers per plant, panicle length, number of grains per panicle, and days to maturity. The biological yield per plant has the most significant positive effect on grain yield, followed by the number of filled grains per plant, panicle weight, number of effective tillers per plant, test weight, panicle length, number of tillers per plant, days to maturity, and days to 50% flowering. Hence, these characters might require more attention in the selection of desirable genotypes to achieve higher grain yields of rice.

Keywords: Diallel, Association, Path coefficient, phenotypic correlation, grain yield

INTRODUCTION

Rice (Oryza sativa L.) is an important cereal food crop for more than half of the global population (EI Sayed *et al*. 2021). It possesses significant nutritional advantages, featuring a high content of carbs, minerals, calories, protein, and vitamins (Kun *et al*. 2013). Its grain consists of carbohydrates (71.1 g), protein (7.3 g), and crude fat (2.2 g) and is low in fiber. Omega-6 fatty acids, considered pro-inflammatory, dominate the fat composition. The globally cultivated area of rice is around 162 million hectares, with a production of 756 million tons (FAOSTAT, 2021). The result must be augmented to address ongoing population growth and imminent climate change (Chang *et al*. 2016).

The largest rice-producing states in India include Uttar Pradesh, West Bengal, Odisha, Bihar, Chhattisgarh, Andhra Pradesh, and Madhya Pradesh. West Bengal is the largest producer of rice, followed by Uttar Pradesh. Rice is an important food grain in terms of production and consumption, occupying 23.3 percent of the nation's gross cultivated area and contributing 43 percent to total food grain production. India has 45.07 million hectares, yielding 122.27 million tonnes, with a productivity of 2713 kg per hectare (Agricultural Statistics at a Glance 2021, Government of India, Ministry of Agriculture and Farmers Welfare, Directorate of Economics and Statistics). In Madhya Pradesh, rice is cultivated over around 1.98 million hectares, yielding 4.52 million tonnes, with a productivity rate of 2270 kg per hectare (Annual Report, 2018-19, Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India).

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MATERIALS AND METHODS

This investigation was conducted at the instructional farm of JNKVV, College of Agriculture, Rewa (M.P.). Rewa is located in the rice-wheat crop zone, specifically within the "Kymore Plateau and Satpura Hills Agro-climatic Zone" of Madhya Pradesh. The climate of Rewa is subtropical, which has an average annual rainfall of 1080 mm. The crosses were made in a diallel fashion using 10 parents in a one-way manner, excluding reciprocals. The experiment was laid out in a randomized block design (RBD) with three replications to evaluate 55 genotypes (45 F1s and 10 parents) during Kharif 2019. Each genotype was transplanted in paired rows of 2 meters, with a spacing of 20 cm by 15 cm. Quantitative trait observations have been recorded from five randomly selected plants from each replication.

RESULTS AND DISCUSSION

The correlation coefficient study showed the strength of the linear relationship between two variables and formed the basis for selection indices, which contributed to crop improvement programs. Comprehending the impact of one character's development on another simultaneously might be beneficial. Grain yield is a polygenic character influenced by environmental factors. Understanding the genetic relationships among the factors affecting yield leads to the most efficient selection approach through advantageous character combinations. Therefore, an essential requirement for effective breeding programs is the orientation and magnitude of component traits associated with yield.

These 12 quantitative traits include days to 50% flowering, days to maturity, plant height, number of tillers per plant, number of effective tillers per plant, panicle length, panicle weight, number of grains per panicle, number of filled grains per panicle, biological yield per plant, test weight, and grain yield per plant. The study discovered a relationship between these traits. The findings of the correlation coefficient study are displayed in Table 1 and elaborated below.

The association studies indicated that grain yield per plant exhibited a highly significant positive correlation with biological yield per plant (0.9309**, 0.9674**), followed by the weight of the panicle (0.8317**, 0.8931**), number of filled grains per panicle (0.4871**, 0.6583**), number of effective tillers per plant (0.4746**, 0.5102**), number of tillers per plant (0.4276**, 0.4343**), panicle length (0.3608**, 0.5089**), number of grains per panicle (0.3243**, 0.4177**), and days to maturity (0.2580**, 0.2852*), which all showed significant associations with grain yield per plant at both phenotypic and genotypic levels, respectively. The estimations of the genotypic correlation coefficient were generally greater than the corresponding phenotypic correlation coefficient for the majority of characters. This suggests that the suppression of environmental influences on characters can facilitate the selection of genotypes with higher grain yield. The current findings align with previous research by Prakash *et al*. (2018) on biological yield per plant, effective tillers per plant, panicle length, and grains per panicle; Fentie *et al*. (2021) on panicle weight and filled grains per panicle; and Kafi *et al*. (2021) on panicle weight, effective tillers per plant, total tillers per plant, and grains per plant. Therefore, selection for the highest grain yield based on these characters would be appropriate.

The study of phenological and yield-attributing variables at both the phenotypic and genotypic levels indicated a highly significant positive relationship between yield attributes. Among phenological traits, days to 50% flowering had a highly significant positive association with days to maturity; days to maturity had a significant positive association with test weight and panicle weight; and plant height with number of grains panicle^{-1} and number of effective tillers plant^{-1}.

In accordance with this, Sadimanthra *et al*. (2021) also reported a positive association of days to 50% flowering with maturity; Jadhav *et al*. (2018) for days to maturity with biological yield plant-1 and weight of panicle; and Mourya *et al*. (2018) for plant height with number of grains plant-1 and effective tillers. Which indicates that these traits are important for yield improvement in rice.

Number of tillers per plant had shown positive association with number of effective tillers plant^{-1}, biological yield plant^{-1}, weight of panicle, number of grains panicle^{-1}, and panicle length. Jadhav *et al.* (2018) also reported a positive and significant association between number of tillers plant^{-1} and number of effective tillers plant^{-1} and Gour *et al.* (2017) found a positive and significant association between the number of tillers plant^{-1}, biological yield plant^{-1} and the weight of the panicle. Number of effective tillers plant^{-1} was positively associated with biological yield plant^{-1}, weight of panicle, number of grains panicle^{-1}, and panicle length. Kafi *et al.* (2021) observed a similar association between the number of effective tillers plant^{-1} and biological yield plant^{-1}, weight of panicle, and number of grains panicle^{-1}.

Panicle length had observed positive association with weight of panicle and biological yield plant^{-1} and weight of panicle with biological yield plant^{-1}, number of filled grains panicle^{-1}, and number of grains panicle^{-1}. Similar associations were also reported between panicle length and biological yield by Abebe *et al*., (2019) and Jadhav *et al*., (2018) for panicle weight with biological yield, number of grains, and number of filled grains panicle^{-1}.

Number of grains panicle^{-1} had observed positive correlation with number of filled grains panicle^{-1} and biological yield plant^{-1}, and number of filled grains panicle^{-1} with biological yield plant^{-1} and biological yield plant^{-1} with test weight. For these traits, similar findings were also reported by Abebe *et al*., (2019).

It indicates that these traits are important for yield improvement in rice. Similarly, Maurya *et al.* (2018) reported a positive association of plant height with the number of grains panicle^{-1} and the number of effective tillers plant^{-1}. Similar associations were also reported by Prakash *et al.* (2018) a significant positive association between the number of effective tillers plant^{-1} and panicle length.

A significant negative association was observed between test weight and plant height, number of tillers plant^{-1}, number of effective tillers plant^{-1}, number of grains panicle^{-1}. Indicate that these traits tend to move in opposite directions. Similar findings, were reported by Islam *et al.* (2015) for plant height; Gour *et al.* (2017) for the number of tillers plant^{-1}; Abebe *et al.* (2019) for the number of effective tillers plant^{-1}; and Bhutta *et al.* (2019) for the number of grains panicle^{-1} with test weight.

Path coefficient analysis (Table 2) revealed that positive and direct effects on grain yield plant^{-1} were recorded in biological yield plant^{-1} (0.5962), followed by number of filled grains panicle^{-1} (0.1867), weight of panicle (.01852), number of effective tillers plant^{-1} (0.1737), test weight (0.0741), panicle length (0.0496), number of tillers plant^{-1} (0.0415), days to maturity (0.0186), and days to 50% flowering (0.0064). The results are in agreement with Gour *et al.* (2017), Islam *et al.* (2015), Saha *et al.* (2019) and Naik *et al.* (2021).

Apart from direct effects, days to 50% flowering had also shown a positive indirect contribution towards grain yield plant^{-1} via biological yield plant^{-1}, followed by days to maturity and test weight. The result was in agreement with Saha *et al.* (2019) and Naik *et al.* (2021), who revealed that days to 50% flowering had a positive direct effect on grain yield plant^{-1}. days to maturity exhibited positive indirect contribution on grain yield plant^{-1} via biological yield, weight of panicle, number of effective tillers plant^{-1}, number of filled grains panicle^{-1}, and test weight. This result was in confirmation with the findings advocated by Sarwar *et al.* (2015), Gour *et al.* (2017), and Barahate *et al.* (2021).

In addition to the negative direct effect on grain yield plant^{-1}, plant height showed an indirect contribution towards grain yield plant^{-1} through test weight, number of effective tillers plant^{-1}, number of filled grains panicle^{-1}, and weight of panicle. Whereas plant height showed a negative indirect effect on grain yield plant^{-1} via days to 50% flowering, panicle length, days to maturity, number of grains panicle^{-1}, and biological yield plant^{-1}. This result was in confirmation with the findings of Gour *et al.* (2017), Naik *et al.* (2021), and Himaja *et al.* (2022).

Apart from direct effects, The number of tillers plant^{-1} exhibited positive indirect effect on grain yield plant^{-1} through biological yield, number of effective tillers plant^{-1}, weight of panicle, panicle length. Whereas the number of tillers plant^{-1} showed a negative indirect effect on grain yield plant^{-1} via plant height, number of grains panicle^{-1}, test weight, and number of filled grains panicle^{-1}. This result was in confirmation with the findings advocated by Sarwar *et al.* (2015), Barahte *et al.* (2021), and Jadahv *et al.* (2018). In contrast to these results for the indirect effect of this trait towards grain yield plant^{-1} via plant height, the number of filled grains panicle^{-1} positive indirect effects reported by Kumar *et al.* (2022) and Kafi *et al.* (2021) also observed positive indirect effects of this trait through test weight. the number of effective tillers plant^{-1} had also shown a positive indirect contribution towards seed yield via biological yield, weight of panicle, number of tillers plant^{-1}, and panicle length. It had also observed a negative indirect effect on grain yield plant^{-1} via plant height, number of grains panicle^{-1}, test weight, and number of filled grains panicle^{-1}. The result was not in agreement with Kafi *et al.* (2021), who revealed the number of effective tillers plant^{-1} had shown a positive indirect effect on grain yield plant^{-1} via the number of grains panicle^{-1}.

In addition to the direct effect on grain yield per plant panicle length, it had contributed indirectly to grain yield plant^{-1} through biological yield and weight of panicle, number of effective tillers plant^{-1}, number of tillers plant^{-1}, test weight, and number of filled grains panicle^{-1}. The result was in confirmation with the findings advocated by Bagudam *et al.* (2018), Gour *et al.* (2017), and Tamatam *et al.* (2018). Weight of panicle evidently has a positive indirect effect on grain yield plant^{-1} via biological yield, followed by number of filled grains panicle^{-1}, number of effective tillers plant^{-1}, panicle length, and number of tillers plant^{-1}. While it showed a negative indirect effect on grain yield plant^{-1} via plant height and number of grains panicle^{-1}. The findings were in agreement with the findings of Bagudam *et al.* (2018), Jadhav *et al.* (2018), and Kafi *et al.* (2021). The result was not in agreement with Kafi *et al.* (2021); they revealed the weight of the panicle had shown a positive indirect effect on grain yield plant^{-1} via the number of grains panicle^{-1}.

A part from the negative direct effect on grain yield plant^{-1}, the number of grains panicle^{-1} evident positive indirect effect on grain yield plant^{-1} via biological yield. While the number of grains panicle^{-1} showed a negative indirect effect on grain yield plant^{-1} via plant height and test weight. This result was in confirmation with the findings advocated by Jadhav *et al.* (2018) for direct effect and Barhate *et al.* (2021), and Kafi *et al.* (2021) for indirect effects. While number of filled grains panicle^{-1} had indirect contribution through biological yield plant^{-1} and weight of panicle. Whereas it had shown the highest negative indirect effect through the number of grains panicle^{-1}. These findings were in agreement with the findings of Islam *et al.* (2015), Fentie *et al.* (2021), Jadhav *et al.* (2018), and Kafi *et al.* (2021).

Biological yield per plant exhibited the highest positive direct effect on grain yield plant^{-1}; it had the highest indirect contribution towards grain yield plant^{-1} through weight of panicle, followed by number of filled grains panicle^{-1}, number of effective tillers plant^{-1}, panicle length, number of tillers plant^{-1}, and test weight. While it had observed a negative indirect effect on grain yield plant^{-1} via the number of grains panicle^{-1}. These findings were influenced by the findings of Gour *et al.* (2017), Bagudam *et al.* (2018), , and Himaja *et al.* (2022). Contrary to this result, the indirect effect of biological yield per plant on grain yield per plant via the number of grains per plant had a positive indirect effect reported by Kafi *et al.* (2021).

Test weight recorded a positive direct effect on grain yield per plant; it also had an indirect contribution through biological yield and number of grains per panicle. A negative indirect contribution of test weight on grain yield plant^{-1} was observed via number of tillers plant^{-1}, number of filled grains panicle^{-1}, and number of effective tillers plant^{-1}. Test weight had observed negligible positive indirect effects on grain yield plant^{-1} via rest traits under study. Similar findings were reported by Naik *et al.* (2021), and Himaja *et al.* (2022). The result was not in agreement with Naseer *et al.* (2015) and Kafi *et al.* (2021), who revealed that test weight recorded a positive indirect effect on grain yield plant^{-1} via number of tillers plant^{-1}.

Table: Phenotypic and Genotypic Correlation of Yield and its Component Traits

S. No.	*Traits*		*DF*	*DM*	*PH (cm)*	*NT*	*NET*	*PL (cm)*	*WP*	*NG*	*NFG*	*BY (gm)*	*TW (gm)*	*GY (gm)*
1	**DF**	**P**	**1.0000**	0.6996 **	-0.0713	0.0567	0.0432	0.0789	0.0407	0.0772	0.0479	0.0820	0.1426	0.1061
		G	**1.0000**	0.8028**	-0.0881	0.0717	0.0647	0.0304	0.0219	0.0941	0.0194	0.0690	0.1639	0.0995
2	**DM**	**P**		**1.0000**	-0.0849	0.0865	0.1067	0.1233	0.1682 *	0.0721	0.0705	0.2549 **	0.1770*	0.2580 **
		G		**1.0000**	-0.0952	0.1301	0.1486	0.1989	0.2053	0.0705	0.0490	0.2982*	0.2015	0.2852*
3	PH (cm)	P			**1.0000**	0.1423	0.1876 *	-0.0283	0.0743	0.2383 **	0.1030	-0.0200	-0.4594 **	0.0034
		G			**1.0000**	0.2056	0.2583	-0.1642	0.1187	0.2868*	0.1408	0.0018	-0.5342**	0.0282
4	**NT**	**P**				**1.0000**	0.9707 **	0.2612 **	0.3188 **	0.2791 **	-0.1110	0.3245 **	-0.2065 **	0.4276 **
		G				**1.0000**	0.9786**	0.4335**	0.4114**	0.4543**	-0.0192	0.3150 *	-0.3095*	0.4343**
5	**NET**	**P**					**1.0000**	0.2581 **	0.3591 **	0.3015 **	-0.0911	0.3823 **	-0.2228 **	0.4746 **
		G					**1.0000**	0.4203**	0.4728**	0.4644**	0.0379	0.4100 **	-0.3156 *	0.5102**
6	**PL (cm)**	**P**						1.0000	0.3137 **	0.0571	0.0496	0.2979 **	0.1374	0.3608 **
		G						**1.0000**	0.4512**	0.1119	0.1122	0.4201**	0.1502	0.5089**
7	**WP**	**P**							**1.0000**	0.3878 **	0.4483 **	0.8143 **	0.0162	0.8317 **
		G							**1.0000**	0.5030 **	0.6557 **	0.9046**	-0.0127	0.8931**
8	**NG**	**P**								1.0000	0.4496 **	0.2775 **	-0.2381 **	0.3243 **
		G								**1.0000**	0.5588 **	0.3813**	-0.2725 *	0.4177**
9	**NFG**	**P**									**1.0000**	0.4448 **	-0.1336	0.4871 **
		G									**1.0000**	0.6061**	-0.2037	0.6583**
10	**BY (gm)**	**P**										**1.0000**	0.1827 *	0.9309 **
		G										**1.0000**	0.1883	0.9674**
11	**TW (gm)**	P											**1.0000**	0.1394
		G											1.0000	0.1221

* Significant at 5% level, **Significant at 1% level

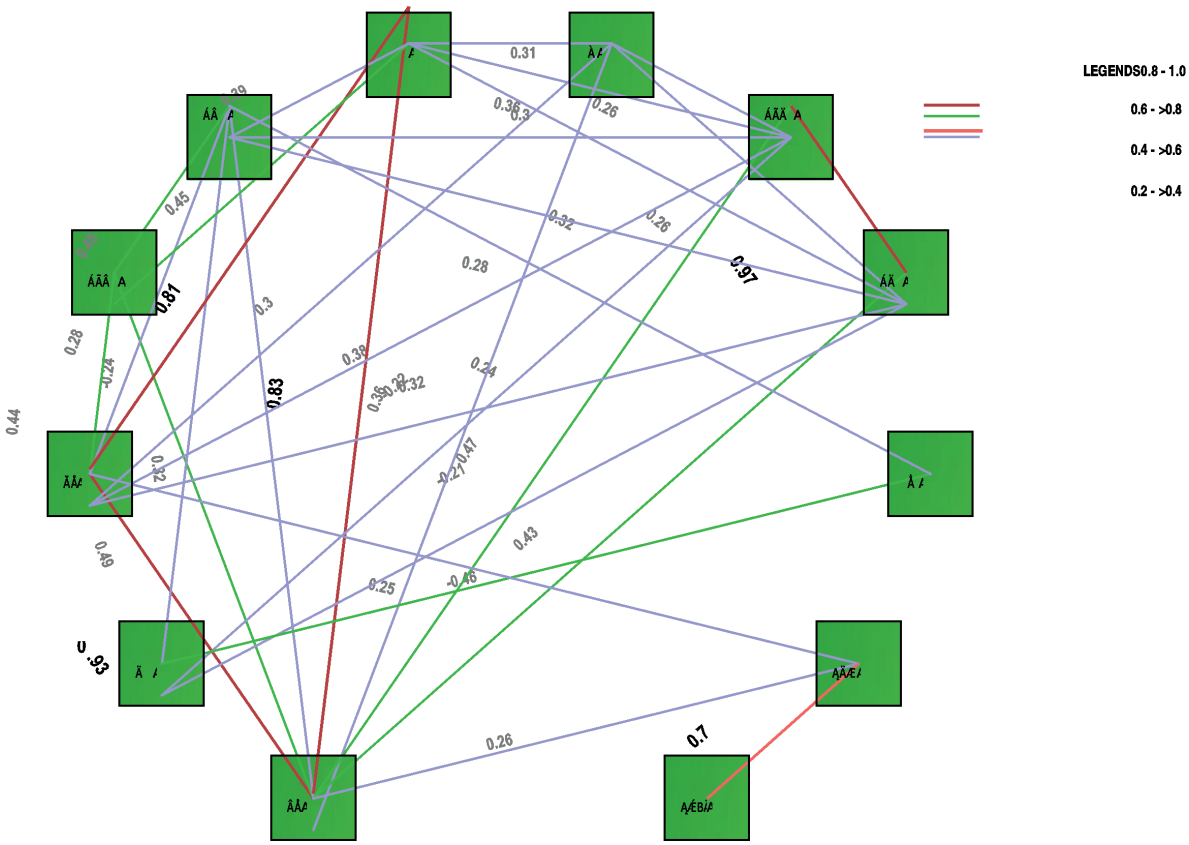
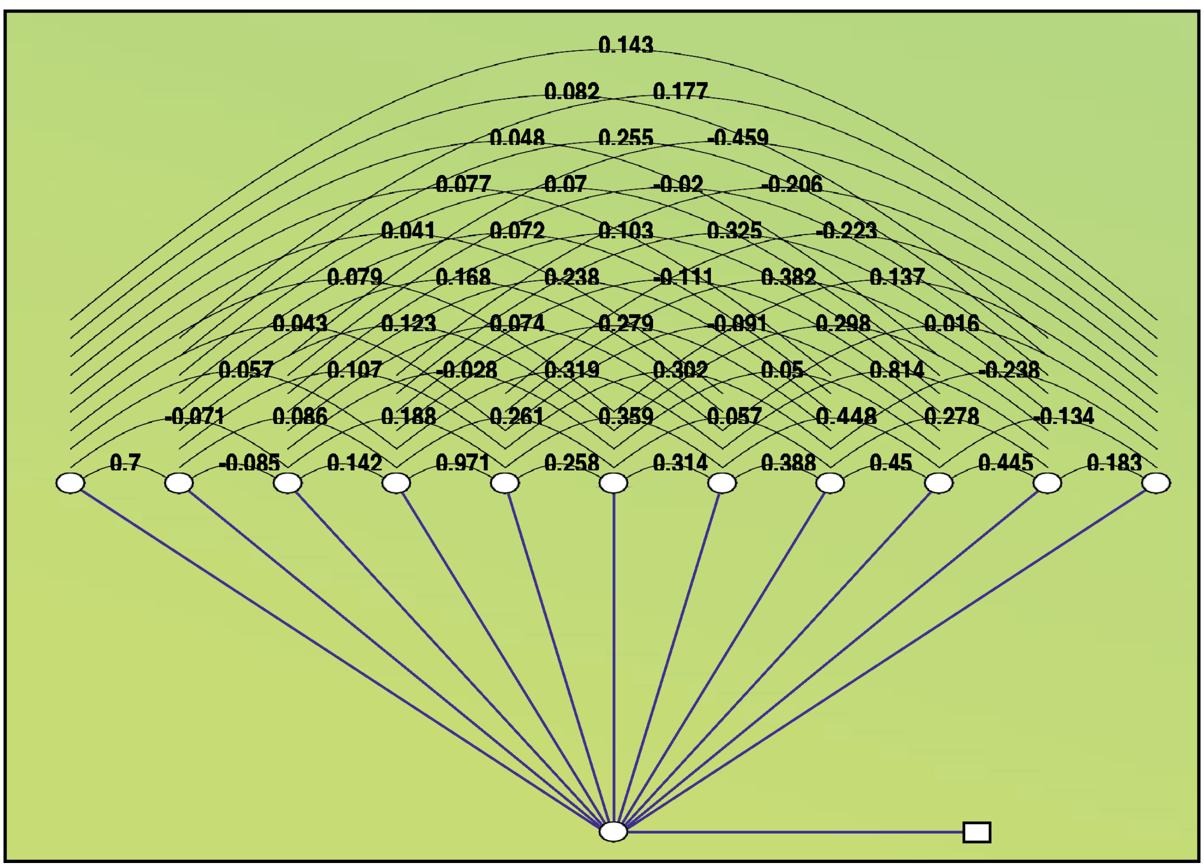


Fig.: Phenotypic correlation diagram showing a positive and negative correlation between yield and its component traits



Path diagram showing direct and indirect relationship between yield and its component traits

Table: Phenotypic Path Direct and Indirect Effects Between Yield and its Component Traits

	DTF	*DTM*	*PH (cm)*	*NOT*	*NOET*	*PL (cm)*	*WOP*	*NOGP*	*NOFGP*	*BYPP (gm)*	*TW (gm)*	*GYPP (gm)*
DTF	**0.0064**	0.0130	0.0005	0.0024	0.0075	0.0039	0.0075	-0.0036	0.0089	0.0489	0.0106	0.1061
DTM	0.0045	**0.0186**	0.0007	0.0036	0.0185	0.0061	0.0311	-0.0033	0.0132	0.1520	0.0131	0.2580**
PH (cm)	-0.0005	-0.0016	**-0.0077**	0.0059	0.0326	-0.0014	0.0138	-0.0110	0.0192	-0.0119	0.0340	0.0034
NOTP	0.0004	0.0016	-0.0011	**0.0415**	0.1686	0.0130	0.0590	-0.0129	-0.0207	0.1935	-0.0153	0.4276**
NOETP	0.0003	0.0020	-0.0014	0.0403	**0.1737**	0.0128	0.0665	-0.0139	-0.0170	0.2279	-0.0165	0.4746**
PL (cm)	0.0005	0.0023	0.0002	0.0109	00.0448	**0.0496**	0.0581	-0.0026	0.0093	0.1776	0.0102	0.3608**
WOP	0.0003	0.0031	-0.006	0.0132	0.0624	0.0155	**0.1852**	-0.0179	0.0837	0.4855	0.0012	0.8317**
NOGPP	0.0005	0.0013	-0.0018	0.0116	0.0524	0.0028	0.0718	**-0.0461**	0.0839	0.1655	-0.0176	0.3243**
NOFGPP	0.0003	0.0013	-0.0008	-0.0046	-0.0158	0.0025	0.0830	-0.0207	**0.1867**	0.2652	-0.0099	0.4871**
BYPP (gm)	0.0005	0.0047	0.0002	0.0135	0.0664	0.0148	0.1508	-0.0128	0.0830	**0.5962**	0.0135	0.9309*
TW (gm)	0.0009	0.0033	0.0035	-0.0086	-0.0387	0.0068	0.0030	0.0110	-0.0249	0.1089	**0.0741**	0.1394

RESIDUAL EFFECT = 0.2848   R SQUARE = 0.9189

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