Short Research Article

Path coefficient analysis for yield and its attributing traits in the induced (M_2) and recurrent irradiated (RM_2) population of finger millet (*Eleusine coracana* L. *Gaertn*)

ABSTRACT

Mutation breeding has evolved as efficient tool for creating novel variability. But studies to adopt recurrent mutagenesis subjecting the first generation (M_1) to another dose of mutagen to examine the possibility of generating more variation compared to induced mutagenesis where treating the base material with a mutagen only once appear to be rare. The present investigation was undertaken during *Kharif*, 2019-20 at the K block, GKVK, University of Agricultural Sciences, Bangalore. The two genotypes of finger millet viz., GPU 28 and KMR 204 have undergone single and recurrent irradiation with different doses of gamma rays (300Gy, 400Gy) and EMS (0.1%) at Bhaba Atomic Research Centre, Mumbai. Observations were recorded for 9 quantitative traits viz., days to 50% flowering, plant height, productive tillers plant^{-1}, ear head plant^{-1}, fingers ear^{-1}, finger length, panicle weight plant^{-1}(g), test weight (g) and grain yield plant^{-1} (g). The two genotypes were assessed for the magnitude of direct and indirect effect of yield attributing traits on grain yield in the induced (M_2) and recurrent irradiated (RM_2) population of finger millet. The studies on path analysis revealed that panicle weight and test weight established positive and direct effect towards grain yield in the induced population of finger millet. Further, in the recurrent irradiated population with gamma rays panicle weight, test weight, finger ear^{-1}, 50% flowering, ear plant^{-1} and finger length showed direct positive effect for grain yield whereas in the recurrent irradiated population with EMS panicle weight followed by test weight, fingers ear$^{-1,}$ plant height, productive tillers plant^{-1}, finger length and 50 % flowering exhibited direct positive effect for grain yield. Henceforth, direct selection based on grain yield and its attributing traits would benefit in developing high yielding variety in the crop improvement programme.

Keywords: path analysis, induced irradiation, recurrent irradiation, finger millet, gamma rays, EMS

1. INTRODUCTION

Finger millet (*Eleusine coracana* L. Gaertn) is an important subsistence cereal in parts of Africa and South Asia. It is commonly known as “Nutritious millet” as the grains are nutritionally rich to many cereals by Negi et al. [1]. This crop is a native of Africa and belongs to the group Chloridoideae, tribe Ergrasetae and family Gramineae. It is an allopolyploid with chromosome number $2n = 4x = 36$ and evolved from a cross between two diploid species, *Eleusine indica* (AA) and *Eleusine floccifolia* or *E. tristachya* (BB) as genome donors given by Kumari and Singh [2]. Nutritionally, finger millet is good source of nutrients like protein (9.2 %), carbohydrate (76.32 %), fat (1.29 %), dietary fibre (18%), phytates (0.48%) and phenolics (0.3% –3%). It is well recognized for its anti-diabetic, anti-ulcer, anti-diarrheal, anti-tumorigenic, antioxidant and antimicrobial properties. Finger millet contains exceptionally higher amount of calcium (300-350mg/100g) among all the small millets. Additionally, Finger millet is an exclusive source of micronutrients and protein in addition to energy and helps in availability of iron and zinc in women and preschool children to fight against malnutrition by Upadyaya et al. [3]. In India the area coverage in ragi is of 1.19 million hectares with production of 1.98 million tonnes with productivity of 1661 kgha^{-1}. The leading states in finger millet production in India are Karnataka followed by Uttarakhand, Maharashtra, Tamil Nadu, Andhra Pradesh, Odisha, Gujarat, Jharkhand and Bihar. Karnataka is the largest producer of finger millet accounting for 58% of its global production.

Finger millet is a self-pollinated crop with small floret size which is quite laborious for emasculation and hybridization. Artificial hybridization and recombination breeding could not be potentially used for varietal breeding programme in finger millet due to the small floret size. Under such circumstances, mutation breeding is the ultimate approach for generating new variability and development of varieties in finger millet. Mutation breeding assists in correcting the defect in an elite cultivar, without losing its agronomic and quality traits. As breeding in finger millet has been going on since several years, exploiting available variability and also generation of variability through hybridization has been made use of to a greater extent. The present need is to create fresh variability. Mutagenesis is expected to be effective in generating variability by altering the genes and also breaking the linkage between alleles. It is therefore necessary to supplement hybridization with mutagenesis. There have been number of attempts in the past to create variability by using different mutagenesis or combination of mutagens called as induced mutagenesis. But studies to adopt recurrent mutagenesis subjecting the first generation (M_1) to another dose of mutagen to examine the possibility of generating more variation compared to induced mutagenesis (where in treating the base material with a mutagen only once) appear to be rare. Khadr et al. [4] tested the effect of irradiation in the seeds of oats with thermal neutrons. They concluded that the new populations developed via recurrent irradiation showed expanded variability over the original population. Cervantes [5] analyzed the variability in SFCAII variety of maize by irradiation with higher doses cobalt 60 gamma rays for four years and the results showed higher variability in the subsequent years. Giura [6] carried out an experiment on wheat by irradiating with gamma rays (200Gy) and again subjected to recurrent irradiation with gamma rays (100Gy, 200Gy) in M_2. They observed a wide spectrum of variability for different morphological characters viz., plant height, leaf dimensions, leaf flag position, ear productivity, ear emergence and maturity time. Sakr et al. [7] studied the effect of recurrent mutagenesis in some induced genotypes of safflower and the results revealed that recurrent mutagenesis helped in developing promising mutants characterized with spineless, earliness, high seed yield and high oil content.

The knowledge of association between traits is important for effective selection of yield in any crop improvement programme however correlation coefficients alone do not elucidate the complexity of the associations between traits or how a change in a trait affects an associated trait. To address this problem, path coefficient, a standardized regression coefficient developed by Wright in 1921, which depicts direct and indirect effects of various traits on a dependent trait. Direct effects are where a trait directly affects another without being influenced by other traits whereas indirect effects occur when the relationship between two traits is mediated by one or more traits. Keeping above scenario in mind, the present investigation was undertaken to study the path coefficient analysis for yield and its attributing traits in the induced (M_2) and recurrent irradiated (RM_2) population of finger millet.

2. MATERIAL AND METHODS

The present study on induced (M_2) and recurrent (RM_2) mutagenesis in finger millet was conducted in *Kharif* 2019 at the K block, GKVK, University of Agricultural Sciences; Bangalore represents Eastern Dry Agro Climatic Zone (Zone V) of Karnataka by following all recommended packages of practices to raise a good crop. Under the BARC project, the two finger millet varieties viz GPU-28 and KMR 204 were treated with gamma rays for different doses viz; 200Gy, 300Gy, 400Gy, 500Gy, along with control earlier (first time irradiation) and the M_1 generation was raised during summer 2019. Based on LD 50 values, 300Gy and 400Gy doses were selected for the present study. A random sample from the bulk M_1 seeds harvested from $M_1$300Gy and $M_1$400Gy treatments of each variety were got irradiated with gamma rays at Bhaba Atomic Research Centre (BARC), Trombay, Mumbai (recurrent irradiation). Part of the seeds irradiated with M_1 300Gy and M_1 400Gy were treated with 0.1% EMS. 6 treatments of GPU 28 and KMR 204 were grown in the field. Totally 12 blocks were there, 6 each for the two varieties GPU 28 and KMR 204. For each treatment of each variety there were 30 rows with 30 plants (Table no.1). After 30 rows of each treatment each of the two checks viz., GPU 28 and KMR 204 was sown in 3 rows with 30 plants in each row. Thus, each blocks pertaining to a treatment consisting of 1080 plants including the checks. The observations were recorded on 150 chosen plants for earliness and yield from each treatment for nine different quantitative characters viz., days to 50% flowering, plant height (cm), productive tillers per plant, ear head per plant, fingers per ear, finger length, panicle weight per plant (g), test weight (g) and grain yield per plant (g). All the statistical analysis was performed using R software. Path coefficient was computed as suggested by Dewey and Lu [8] which provides basic understanding of direct and indirect contribution of various independent characters on the dependent character. Thus, the treatments were as follows:

300GyM_2- Population raised from the seed of M_1 (300Gy) plants

$400GyM_2$- Population raised from the seed of M_1 (400Gy) plants

$300GyRM_2$ - Population raised from the seed of M_1 (300Gy) that was again irradiated with 300Gy

$400GyRM_2$ -Population raised from the seed of M_1 (400Gy) that was again irradiated with 400Gy

$300GyRM_2$ + 0.1%EMS- Population raised from the seed of M_1 (300Gy) that was again irradiated with 300Gy and was treated with 0.1% EMS

$400GyRM_2$ + 0.1%EMS- Population raised from the seed of M_1 (400Gy) that was again irradiated with 400Gy and was treated with 0.1% EMS

Table 1. Population size raised in different treatments of the two varieties

Population	Combination of treatment Dosages	No of Progenies	No of plants in each row
Induced (single irradiation)	**$300GyM_2$**	30	30
	$400GyM_2$	30	30
Recurrent (repeated irradiation)	**$300GyRM_2$**	30	30
	$400GyRM_2$	30	30
	$300GyRM_2$ + 0.1%EMS	30	30
	$400GyRM_2$ + 0.1%EMS	30	30
Control	**No irradiation**	6	30

3. RESULT AND DISCUSSION

3.1 Path coefficient analysis

Path analysis provides the cause and effect relationship between variables. It discloses whether the association of characters with grain yield is due to direct effect or result of their indirect effect through the corresponding trait. Total eight characters were taken under consideration and partitioned into direct and indirect effects using grain yield as dependent variable.

3.1.1 Path coefficient analysis in the induced population (M_2)

Studies on the present investigation revealed that in the induced population (M_2) of KMR 204, grain yield exhibited highest direct effect with panicle weight (0.9965) followed by test weight (0.0314) and fingers ear^{-1} (0.0271) while ear plant^{-1}(-0.0628) recorded highest negative direct effect followed by plant height (-0.0232), finger length (-0.0058), productive tillers plant^{-1}(-0.0056) and 50% flowering (-0.0015) indicating that selection based on these traits would help in identification of favorable genotypes with high yielding potential in future. The trait panicle weight exhibited highest positive indirect effect on grain yield via test weight (0.9410) followed by panicle weight via ear plant^{-1} (0.5918) and panicle weight via finger length (0.4241). However, highest negative indirect effect was exhibited by fifty per cent flowering via panicle weight (-0.4586) followed by ear plant^{-1} via panicle weight (-0.0373), ear plant^{-1} and test weight (-0.0351) (Table 2). Further, in the induced population (M_2) of GPU 28, among eight characters five characters exhibited positive direct effect and other three showed negative direct effect on grain yield. The character panicle weight (0.9896) exhibited highest direct effect on grain yield followed by 50% flowering (0.0296), test weight (0.0096), tillers plant^{-1} (0.0074) and plant height (0.0042) while ear plant^{-1}(-0.0258) recorded higher negative direct effect followed by finger length (-0.0052), and fingers ear^{-1}(-0.0016). Similar results of direct effect of panicle weight, 50% flowering and test weight with grain yield was reported by Deshmukh et al. [9], Gohel and Chaudhari [10] and Shivaprasad et al. [11]. The trait panicle weight exhibited highest positive indirect effect on grain yield via productive tillers plant^{-1} (0.5649) followed by panicle weight via finger length (0.4857) and panicle weight via plant height (0.4395). However, highest negative indirect effect was exhibited by fifty per cent flowering via ear plant^{-1}(-0.0117) followed by ear plant^{-1} via panicle weight (-0.0113), ear plant^{-1} and productive tillers plant^{-1}(-0.0095) (Table 3).

3.1.2 Path coefficient analysis in the recurrent irradiated population (RM_2) with gamma rays

In recurrent irradiated population of KMR 204 with gamma rays, out of eight characters six characters showed positive and two characters showed negative direct effects on grain yield. The highest positive direct effect was recorded by panicle weight (0.9074) followed by test weight (0.0708), finger ear^{-1} (0.0519), 50% flowering (0.0245), ear plant^{-1}(0.0104) and finger length (0.0087). The results were in agreement with results obtained by Jadhav et al. [12], Deshmukh et al. (2018), Gohel and Chaudhari (2018) and Shivaprasad et al. (2019). Negative and high direct effect was recorded by productive tillers plant^{-1} (-0.0286) and plant height (-0.0131). The simultaneous selection can be practiced for all these positive direct effect traits for improvement of grain yield in finger millet. Test weight exhibited a positive high indirect effect on grain yield via panicle weight (0.7726) followed by panicle weight via finger ear^{-1} (0.5422) and plant height (0.5417). High value of negative indirect effect on grain yield plant^{-1} was exhibited by panicle weight via 50% flowering (-0.0886) followed by ear plant^{-1} via productive tillers plant^{-1} (-0.0164) and test weight via productive tillers plant^{-1} (-0.0135) (Table 4). Similarly, in recurrent irradiated population of GPU 28 with gamma rays, out of eight characters six characters showed positive and two characters showed negative direct effects on grain yield (Table 5). The highest positive direct effect recorded by panicle weight (0.8374) followed by finger ear^{-1} (0.2193), test weight (0.1182), productive tillers plant^{-1} (0.0578), 50% flowering (0.0246) and finger length (0.0187). Negative and high direct effect was recorded for ear plant^{-1} (-0.0381) and plant height (-0.0354). Test weight exhibited a positive high indirect effect on grain yield via panicle weight (0.7013) followed by panicle weight via plant height (0.4939) and ear plant^{-1} (0.4837). High value of negative indirect effect on grain yield plant^{-1} was exhibited by panicle weight via fifty per cent flowering (-0.2578) followed by finger ear^{-1} via fifty per cent flowering (-0.0350) and ear plant^{-1} via panicle weight (-0.0220). These traits could be used as indirect selection criteria for higher grain yield.

3.1.3 Path coefficient analysis in the recurrent irradiated population (RM_2) with EMS

In recurrent irradiated population of KMR 204 with EMS, out of eight traits seven traits exerted positive and one trait showed negative direct effects on grain yield. Highest positive direct effect was recorded by panicle weight (0.9073) followed by test weight (0.0741), fingers ear^{-1}(0.0461), plant height (0.0278), productive tillers plant^{-1}(0.0207), finger length (0.0205) and 50 % flowering (0.0083). The results were in close association with the findings of Wolie and Dessalegn [13], Jyothsna et al. [14], Deshmukh et al. (2018) and Shivaprasad et al. (2019). Hence, the direct positive effect traits could be considered as a selection index for the improvement of grain yield in finger millet. Negative direct effect was observed for ear plant^{-1} (-0.0423). Test weight showed a highly positive indirect effect on seed yield via panicle weight (0.8599) followed by panicle weight via ear head plant^{-1} (0.6732), panicle weight via productive tillers plant^{-1} (0.4740). High value of negative indirect effect on seed yield plant^{-1} was showed by ear plant^{-1} via test weight (-0.0317) followed by ear plant^{-1} via panicle weight (-0.0314) and ear plant^{-1} via productive tillers plant^{-1} (-0.0141) (Table 6). Similarly, in recurrent irradiated population of GPU 28 with EMS, out of eight traits seven traits exerted positive and one trait showed negative direct effect on grain yield. Highest positive direct effect was recorded by panicle weight (0.7843) followed by test weight (0.01531), fingers ear^{-1}(0.0623), plant height (0.0553), productive tillers plant^{-1}(0.0377), ear plant^{-1} (0.0185) and 50 % flowering (0.0062). Negative direct effect was observed for finger length (-0.0623). These findings are in agreement with reports of Ganapathy et al. [15] studied number of productive tillers per plant had shown high direct effect on grain yield and indirect effect was shown by finger numbers per ear and finger length. Test weight showed highly positive indirect effect on grain yield via panicle weight (0.7495) followed by panicle weight via ear head plant^{-1} (0.6464) and finger length (0.5250) indicating that improvement of these traits would also improve the grain yield indirectly. High value of negative indirect effect on grain yield plant^{-1} was exhibited by finger length via plant height (-0.0456) followed by finger length via panicle weight (-0.0430) and finger length via test weight (-0.0411) (Table 7).

4. CONCLUSION

Considering the magnitude of direct and indirect effect of yield attributing traits on grain yield in the induced (M_2) and recurrent irradiated (RM_2) population of finger millet, it can be inferred that panicle weight and test weight could serve as important trait for formulating an effective strategy for direct selection of the high yielding genotypes in finger millet. Further, the character panicle weight via test weight exhibited positive indirect effect is also considered simultaneously for the indirect selection of genetic improvement of grain yield. Path coefficient analysis provides a direction for selection of these traits which would be rewarding for the improvement of yield in finger millet. Ultimately, it brings opportunity to the breeder for the improvement in grain yield via direct and indirect selection along with improving these traits through hybridization.

Table 2: Estimates of direct and indirect effect at phenotypic level of yield related traits in M_2 generation in KMR 204

	Days to 50 per cent flowering	Plant height (cm)	Productive tillers plant^{-1}	Ear head plant^{-1}	Fingers ear^{-1}	Finger length	Panicle weight plant^{-1}	Test weight (g)
Days to 50% flowering	**-0.0015**	0.0004	0.0002	0.0004	0.0003	0.0003	0.0007	0.0007
Plant height	0.0064	**-0.0232**	0.0021	-0.0001	-0.0010	-0.0070	-0.0033	-0.0050
Productive tillers plant^{-1}	0.0007	0.0005	**-0.0056**	-0.0025	-0.0005	-0.0016	-0.0022	-0.0018
Ear head plant^{-1}	0.0184	-0.0003	-0.0276	**-0.0628**	-0.0064	-0.0289	-0.0373	-0.0351
Fingers ear^{-1}	-0.0062	0.0011	0.0026	0.0027	**0.0271**	0.0063	0.0095	0.0098
Finger length	0.0013	-0.0017	-0.0016	-0.0027	-0.0014	**-0.0058**	-0.0025	-0.0026
Panicle weight plant^{-1}(g)	-0.4586	0.1425	0.3900	0.5918	0.3501	0.4241	**0.9965**	0.9410
Test weight (g)	-0.0145	0.0068	0.0099	0.0175	0.0114	0.0140	0.0297	**0.0314**
r value	-0.4541	0.1260	0.3699	0.5444	0.3797	0.4015	0.9911	0.9384

Residual effect = 0.1159

Table 3: Estimates of direct and indirect effect at phenotypic level of yield related traits in M_2 generation in GPU 28

	Days to 50 per cent flowering	Plant height (cm)	Productive tillers plant^{-1}	Ear head plant^{-1}	Fingers ear^{-1}	Finger length	Panicle weight plant^{-1}	Test weight (g)
Days to 50% flowering	**0.0296**	0.0098	0.0019	-0.0117	0.0101	0.0137	0.0050	0.0063
Plant height	0.0014	**0.0042**	0.0006	-0.0014	0.0017	0.0026	0.0019	0.0009
Productive tillers plant^{-1}	0.0005	0.0010	**0.0074**	0.0027	0.0010	0.0018	0.0042	0.0017
Ear head plant^{-1}	0.0102	0.0085	-0.0095	**-0.0258**	0.0022	0.0086	-0.0113	-0.0010
Fingers ear^{-1}	-0.0005	-0.0006	-0.0002	0.0001	**-0.0016**	-0.0007	-0.0006	-0.0003
Finger length	-0.0024	-0.0033	-0.0013	0.0017	-0.0024	**-0.0052**	-0.0026	-0.0016
Panicle weight plant^{-1}(g)	0.1670	0.4395	0.5649	0.4313	0.3593	0.4857	**0.9896**	0.3017
Test weight (g)	0.0021	0.0020	0.0022	0.0004	0.0018	0.0029	0.0029	**0.0096**
r value	0.2078	0.4611	0.5661	0.3973	0.3722	0.5093	0.9892	0.3174

Residual effect = 0.1387

Table 4: Estimates of direct and indirect effect at phenotypic level of yield related traits in RM_2 generation with gamma rays in KMR 204

	Days to 50 per cent flowering	Plant height (cm)	Productive tillers plant^{-1}	Ear head plant^{-1}	Fingers ear^{-1}	Finger length	Panicle weight plant^{-1}	Test weight (g)
Days to 50% flowering	**0.0245**	0.0097	-0.0068	-0.0091	0.0036	-0.0024	-0.0024	-0.0031
Plant height	-0.0052	**-0.0131**	-0.0011	-0.0001	-0.0068	-0.0048	-0.0078	-0.0059
Productive tillers plant^{-1}	0.0079	-0.0025	**-0.0286**	-0.0164	-0.0049	-0.0006	-0.0116	-0.0135
Ear head plant^{-1}	-0.0039	0.0001	0.0059	**0.0104**	0.0016	0.0008	0.0051	0.0045
Fingers ear^{-1}	0.0075	0.0267	0.0089	0.0081	**0.0519**	0.0115	0.0310	0.0262
Finger length	-0.0008	0.0032	0.0002	0.0006	0.0019	**0.0087**	0.0034	0.0025
Panicle weight plant^{-1}(g)	-0.0886	0.5417	0.3693	0.4489	0.5422	0.3483	**0.9074**	0.7726
Test weight (g)	-0.0091	0.0320	0.0335	0.0311	0.0357	0.0205	0.0603	**0.0708**
r value	-0.0677	0.5978	0.3813	0.4735	0.6253	0.3821	0.9853	0.8541

Residual effect = 0.1587

Table 5: Estimates of direct and indirect effect at phenotypic level of yield related traits in RM_2 generation with gamma rays in GPU 28

	Days to 50 per cent flowering	Plant height (cm)	Productive tillers plant^{-1}	Ear head plant^{-1}	Fingers ear^{-1}	Finger length	Panicle weight plant^{-1}	Test weight (g)
Days to 50% flowering	**0.0246**	-0.0065	0.0020	-0.0039	-0.0039	-0.0089	-0.0076	-0.0011
Plant height	0.0094	**-0.0354**	0.0010	-0.0090	-0.0058	-0.0201	-0.0209	-0.0147
Productive tillers plant^{-1}	0.0046	-0.0016	**0.0578**	0.0174	0.0158	-0.0061	0.0048	0.0079
Ear head plant^{-1}	0.0060	-0.0097	-0.0115	**-0.0381**	-0.0087	-0.0056	-0.0220	-0.0186
Fingers ear^{-1}	-0.0350	0.0361	0.0600	0.0503	**0.2193**	0.0436	0.0528	0.0858
Finger length	-0.0067	0.0106	-0.0020	0.0027	0.0037	**0.0187**	0.0074	0.0056
Panicle weight plant^{-1}(g)	-0.2578	0.4939	0.0703	0.4836	0.2017	0.3294	**0.8374**	0.7013
Test weight (g)	-0.0054	0.0491	0.0161	0.0577	0.0462	0.0353	0.0090	**0.1182**
r value	-0.2604	0.5365	0.1937	0.5607	0.4683	0.3864	0.9509	0.8842

Residual effect = 0.9751

Table 6: Estimates of direct and indirect effect at phenotypic level of yield related traits in RM_2 generation with EMS in KMR 204

	Days to 50 per cent flowering	Plant height (cm)	Productive tillers plant^{-1}	Ear head plant^{-1}	Fingers ear^{-1}	Finger length	Panicle weight plant^{-1}	Test weight (g)
Days to 50% flowering	**0.0083**	0.0022	0.0039	-0.0010	0.0028	0.0019	0.0021	0.0015
Plant height	0.0073	**0.0278**	0.0094	0.0023	0.0065	0.0132	0.0052	0.0023
Productive tillers plant^{-1}	0.0096	0.0070	**0.0207**	0.0069	0.0059	0.0074	0.0108	0.0094
Ear head plant^{-1}	0.0052	-0.0035	-0.0141	**-0.0423**	-0.0115	-0.0101	-0.0314	-0.0317
Fingers ear^{-1}	0.0156	0.0107	0.0131	0.0125	**0.0461**	0.0149	0.0199	0.0166
Finger length	0.0046	0.0098	0.0074	0.0049	0.0066	**0.0205**	0.0071	0.0045
Panicle weight plant^{-1}(g)	0.2250	0.1684	0.4740	0.6732	0.3911	0.3126	**0.9073**	0.8599
Test weight (g)	0.0130	0.0061	0.0337	0.0556	0.0267	0.0164	0.0702	**0.0741**
r value	0.2886	0.2284	0.5479	0.7121	0.4743	0.3769	0.9911	0.9366

Residual effect = 0.1086

Table 7: Estimates of direct and indirect effect at phenotypic level of yield related traits in RM_2 generation with EMS in GPU 28

	Days to 50 per cent flowering	Plant height (cm)	Productive tillers plant^{-1}	Ear head plant^{-1}	Fingers ear^{-1}	Finger length	Panicle weight plant^{-1}	Test weight (g)
Days to 50% flowering	**0.0062**	-0.0002	-0.0010	-0.0006	-0.0009	0.0000	0.0013	0.0009
Plant height	-0.0017	**0.0553**	0.0414	0.0298	0.0186	0.0393	0.0340	0.0312
Productive tillers plant^{-1}	-0.0061	0.0282	**0.0377**	0.0259	0.0123	0.0201	0.0210	0.0218
Ear head plant^{-1}	-0.0019	0.0099	0.0127	**0.0185**	0.0081	0.0090	0.0152	0.0144
Fingers ear^{-1}	-0.0095	0.0210	0.0203	0.0273	**0.0623**	0.0302	0.0321	0.0310
Finger length	0.0003	-0.0456	-0.0342	-0.0313	-0.0312	**-0.0643**	-0.0430	-0.0411
Panicle weight plant^{-1}(g)	0.1612	0.4818	0.4355	0.6464	0.4046	0.5250	**0.7843**	0.7495
Test weight (g)	0.0226	0.0864	0.0886	0.1192	0.0763	0.0978	0.1464	**0.1531**
r value	0.1711	0.6369	0.6009	0.8354	0.5500	0.6571	0.9912	0.9610

Residual effect = 0.0951

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