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Correlation and Path Coefficients Analysis for Seed Yield and Micronutrients in Mungbean (*Vigna radiata* (L.) Wilczek)

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ABSTRACT

Seventy mungbean RILs (F_6 generation), made from a cross between ML-776 (high zinc and iron content) and MH 2-15 (MYMV resistant, high seed yield and low zinc and iron content), were evaluated for yield traits and Zn and Fe content in seeds in two environments during kharif 2015 to identify the selection indices with an eye on comprehensive biofortification programme. Seed yield was found to have positive significant correlation with plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight, biological yield and harvest index and negatively with days to flowering, days to maturity and reaction to MYMV. Zinc content exhibited significant positive correlation with iron content, however, no association of the micronutrients was observed with seed yield. Path coefficient analysis indicated that number of pods plant^{-1}, number of seeds pod^{-1}, biological yield plot^{-1} and harvest index had maximum direct contribution on seed yield hence these characters should be given due importance while formulating selection criteria for seed yield.

Key words: *Mungbean, RILs, Correlation and path coefficients analysis.*

INTRODUCTION

Mungbean (*Vigna radiata* (L.) Wilczek) is an important pulse crop of tropical, subtropical and temperate zone of Asia. It is also cultivated in Australia, East Africa and United States of America and belongs to the subgenus *Ceratotropis* in the *Leguminosae* genus *Vigna*, the tribe *Phaseoleae* and the family *Fabaceae*. Mungbean is an excellent source of dietary protein of low flatulence which complements the staple wheat and rice diet in Asia and it represents a cheap source of carbohydrates, folate and iron besides high-quality protein[1]. Its short duration enables it to fit well in many cropping systems and can be grown sole as well as intercrop. Till now major emphasis has been laid to improve the crop productivity with little concern to nutritional value or health promoting qualities of food being produced. Micronutrient malnutrition is recognized as a massive and rapidly growing public health issue especially among poor people.

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Micronutrient malnutrition causes several diseases and the affected people are more prone to infection by other diseases resulting in further deterioration in quality of life[2]. Zinc and iron are important micronutrients which are required to maintain metabolic regulation and organ function[3]. Numerous strategies have been employed to combat micronutrient deficiency, however, biofortification has come up as a most feasible strategy to cope up with micronutrient malnutrition[4,5].

Considering the diverse growing conditions of mungbean, its varied food products and their ease in digestion, emphasis should be laid on developing new mungbean varieties with high zinc and iron content which can improve the nutritional status of vegetarian population. Yield is the most complex trait and is the end product of interaction of many correlated characters and selection for yield would be effective when based on the characters, which are highly heritable and positively correlated. The importance of knowledge of correlation and path coefficients is particularly appreciable when highly heritable characters associated with complex trait like yield are identified and successfully used as criteria for effective selection. In mungbean, different combinations of agronomic and physiological characters have been reported as important criteria for yield improvement; however, the results appeared to vary depending on different plant populations and environmental conditions. Therefore, the present investigation was undertaken to determine the correlation of yield component characters and zinc and iron with seed yield and their direct and indirect effects in Recombinant Inbred Lines (RILs) of mungbean developed using highly diverse parents for zinc and iron content in seeds.

MATERIALS AND METHODS

Field experiment was carried out in *kharif* 2015 at Pulses Research Area of Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. The experimental material for the present investigation comprised of 70 mungbean recombinant inbred lines (RILs) in F_6 generation, their two parents [ML-776 (high zinc and iron content) and MH 2-15 (MYMV resistant, high seed yield and low zinc and iron content)] and three popular cultivated varieties of mungbean as yield checks (MH 1-25, MH 421 and MH 318). The experiment was conducted in two sets *i.e.* untreated - with only Recommended Doses of Fertilizer (RDF) and treated - with RDF + 25 kg/ha $ZnSO_4$ as basal dose and 0.5% solution of $FeSO_4$ as foliar spray at flowering stage. Both the sets of the experiment were laid out in Randomized Block Design with three replications. All the genotypes were grown in 2 rows×2 m plot with 30×10 cm spacing.

The observations were recorded as the means from five randomly selected plants from each genotype in each replication for plant height, number of branches plant^{-1}, number of pods plant^{-1} and number of seeds pod^{-1}. The traits like days to 50% flowering, days to maturity, 100-seed weight, seed yield plot^{-1}, biological yield plot^{-1}, harvest index, reaction to Mungbean Yellow Mosaic Virus (MYMV) were determined on plot basis. Zinc and iron content in seeds were estimated by following the Atomic Absorption Spectrophotometer (AAS) analysis of Benton-Jones[6] based on nitric/perchloric acid digestion. The correlation coefficients among all character combinations at phenotypic and genotypic levels were estimated as per method suggested Al-Jibouri et al[7] and path coefficient analysis as per by Dewey and Lu[8].

RESULTS AND DISCUSSION

Seed yield is a complex character and can be viewed as an end product of many component characters as various characters tend to show interrelationship. Therefore, correlation coefficients were estimated for all the characters studied with seed yield and among the characters themselves at both genotypic and phenotypic levels under untreated and treated environments (Tables 1 and 2, respectively). Though, the significance of genotypic correlation could not be tested, as no suitable statistical test is available[9], their magnitude in relation to their corresponding phenotypic value form a sound basis for inferring their practical implication. By and large the correlation coefficients at genotypic level were greater in magnitude than that of corresponding phenotypic coefficients indicating inherent association among the characters and implied that phenotypic selection will be effective[10]. Independent t-test applied to study the effect of iron and zinc application on various yield characters and zinc and iron content in seeds revealed that genotypes performed better under treated environment than the untreated environment for traits *viz*. plant height, number of branches plant^{-1}, 100-seed weight, seed and biological yield plot^{-1} and micronutrients zinc and iron content in seeds. Previous studies of Singh et al[3] also support our findings. Similar associations between seed yield and other traits were observed in both the environments, however, the magnitude varied.

Seed yield plot^{-1} was found significantly and positively associated with plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight, biological yield plot^{-1} and harvest index. These results show unanimity with those conceived by a number of previous studies[11,12,13,14,15,16]. This indicated that these characters are major yield contributing ones and are expected to bring significant positive changes in seed yield. Further, seed yield plot^{-1} was found negatively associated with days to flowering, days to maturity and reaction to MYMV which showed concurrence with the findings of Tabasum et al[10], Bharti et al[17], Niharika et al[18] and Raturi et al[19]. No significant association was observed between seed yield and zinc and iron content in seeds.

Correlation among the component characters themselves revealed that plant height had significant positive correlation with days to flowering, days to maturity, number of branches plant, number of pods plant^{-1}, seed and biological yield plot^{-1} at phenotypic level. Number of pods plant^{-1} showed significant positive correlation with plant height, number of branches plant^{-1}, 100-seed weight, seed yield plot^{-1}, biological yield plot^{-1} and harvest index. Significant positive association was exhibited by 100-seed weight with number of pods plant^{-1}, seed yield and biological yield plot^{-1}. These results are in partial confirmation with that of Tabasum et al[10], Kumar et al[20] and Sahu et al[21]. Number of branches plant^{-1} showed positive significant correlation with days to flowering, days to maturity, plant height, number of pods plant^{-1}, seed and biological yield plot^{-1} and harvest index at phenotypic level. It could be understood that more number of primary branches would increase the number of pods plant^{-1} and consequently the seed yield.

Zinc content was found positively and significantly correlated with iron content however, no association of the micronutrients was observed with seed yield. In several studies on micronutrients in different crops, significant positive correlation between zinc and iron concentration have been reported (Cakmak et al[22] in wheat; Stangoulis et al[23] in rice and Blair et al[24] in *Phaseolus vulgaris*). A highly significant positive correlation between Zn and Fe concentrations in 1000 accessions of common bean was also found by Welch and Graham[5] which was confirmed by Tryphone and Masolla[25]. These results suggest that genotypes those have more number of seeds pod^{-1}, higher number of pods plant^{-1}, increased number of clusters plant^{-1} and delayed flowering and maturity give higher seed yield and hence simultaneous selection based on these characters could be envisaged for improvement in yield.

Path analysis technique furnishes a method of partitioning the correlation coefficients between various characters in to direct and indirect effect, provides the actual contribution of an attribute and its influence through the other traits and act as an effective tool to identify components to be used as potential selection criteria. Path coefficients of component traits determining the seed yield and are presented in Table 3 and 4 for untreated and treated environments, respectively. High positive direct effect on seed yield plot^{-1} was exercised by biological yield plot^{-1}, harvest index, number of pods plant^{-1} and number of seeds pod^{-1}. The direct effect of biological yield plot^{-1} was positive and its association with seed yield plot^{-1} was positively significant due to high positive indirect effects via number of branches plant^{-1}, number of pods plant^{-1} and number of seeds pod^{-1} in both the environments. Similarly, harvest index exerted positive indirect effects via number pods plant^{-1} and number of seeds pod^{-1} and resulted in significant positive association with seed yield. Number of seeds pod^{-1} exerted highest negative indirect effect on seed yield plot^{-1}. Plant height and number of branches plant^{-1} recorded high positive indirect effect on seed yield via number of pods plants^{-1}. Reddy et al[26] reported that days to flowering, days to maturity, number of pods plant^{-1}, shoot dry matter plant^{-1} and 100-seed weight had positive direct effects on seed yield whereas, Srivastava and Singh[27] indicated that number of pods plant^{-1}, number of seeds pod^{-1}, number of clusters plant^{-1} had maximum direct contribution on seed yield. Garje et al[28] reported that number of pod plant^{-1} had maximum direct effect on seed yield followed by number of cluster plant^{-1} and number of secondary branches plant^{-1}.

Number of pods plant^{-1}, number of seeds pod^{-1}, biological yield plot^{-1} and harvest index showed positive significant association and high positive direct effects on seed yield and high indirect effects via many of the characters. Thus, these are the characters that are of prime importance in determining seed yield and hence, should be given due importance while formulating selection criteria in the later segregating generations for the production of elite genotypes for seed yield.

Table 1: Estimates for phenotypic and genotypic correlation coefficients in mungbean under untreated environment

	Days to 50% flowering	Days to maturity	Plant height	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	100-seed weight	Seed yield plot^{-1}	Biological yield plot^{-1}	Harvest index	Reaction to MYMV	Zinc content (mg/kg seed)	Iron content (mg/kg seed)
Days to 50% flowering		0.560**	0.217**	0.311**	-0.241**	-0.043	-0.444**	-0.320**	-0.077	-0.111	0.082	0.066	-0.017
Days to maturity	0.673		0.370**	0.139*	-0.110	0.030	-0.364**	-0.380**	-0.026	-0.088	0.073	0.039	-0.008
Plant height	0.296	0.470		0.191**	0.350**	0.093	-0.098	0.311**	0.389**	-0.444**	-0.350**	-0.117	-0.080
No. of branches plant^{-1}	-0.376	-0.185	0.246		0.634**	0.034	0.074	0.665**	0.666**	0.214**	-0.388**	0.034	0.041
No. of pods plant^{-1}	-0.367	-0.081	0.507	0.888		0.085	0.148*	0.769**	0.780**	0.139*	-0.366**	-0.036	-0.037
No. of seeds pod^{-1}	-0.082	-0.053	0.305	0.679	0.708		-0.382**	0.396**	0.412**	0.037	-0.395**	0.068	0.098
100-seed wt.	-0.511	-0.448	-0.255	0.225	0.230	-0.169		0.271**	0.307**	-0.035	-0.332**	0.115	-0.065
Seed yield plot^{-1}	-0.409	-0.154	0.418	0.877	1.088	0.589	0.376		0.840**	0.446**	-0.655**	0.033	-0.056
Biological yield plot^{-1}	-0.314	-0.022	0.453	0.798	0.998	0.535	0.355	0.972		-0.292**	-0.686**	0.029	-0.127
Harvest index	-0.426	-0.536	-0.023	0.435	0.517	0.339	0.056	0.217	-0.022		-0.083	0.017	-0.051
Reaction to MYMV	0.479	0.181	-0.359	-0.726	-0.852	-0.486	-0.419	-0.847	-0.788	-0.398		-0.047	0.058
Zinc content	0.070	0.199	-0.158	0.061	-0.063	0.104	0.130	0.050	0.028	0.112	-0.074		0.312**
Iron content	-0.009	0.002	-0.322	0.043	-0.164	0.294	-0.074	-0.059	-0.136	-0.119	0.087	0.337	

* Significant at p= 0.05; ** Significant at p= 0.01; MYMV- Mungbean Yellow Mosaic Virus

Above diagonal- phenotypic correlation coefficients; Below diagonal- genotypic correlation coefficients

Table 2: Estimates for phenotypic and genotypic correlation coefficients in mungbean under treated environment

	Days to 50% flowering	Days to maturity	Plant height	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	100-seed weight	Seed yield plot^{-1}	Biological yield plot^{-1}	Harvest index	Reaction to MYMV	Zinc content (mg/kg seed)	Iron content (mg/kg seed)
Days to 50% flowering		0.467**	0.146*	0.283**	-0.283**	-0.130	-0.466**	-0.360**	-0.072	-0.004	0.121	0.082	-0.006
Days to maturity	0.620		0.250**	0.163*	-0.074	-0.039	-0.387**	-0.143*	-0.110	-0.090	0.008	0.053	-0.002
Plant height	0.175	0.393		0.223**	0.407**	0.062	-0.033	0.227**	0.292**	-0.138*	-0.328**	-0.006	-0.085
No. of branches plant^{-1}	-0.332	-0.198	0.261		0.631**	0.109	0.052	0.652**	0.724**	0.481**	-0.363**	0.095	0.122
No. of pods plant^{-1}	-0.366	-0.113	0.480	0.816		0.099	0.148*	0.781**	0.814**	0.399**	-0.233**	0.011	0.025
No. of seeds pod^{-1}	-0.181	-0.119	0.138	0.595	0.602		-0.465**	0.352**	0.455**	-0.086	-0.411**	0.112	0.046
100-seed wt.	-0.549	-0.510	-0.322	0.155	0.154	-0.592		0.247**	0.250**	0.018	-0.162*	0.094	-0.089
Seed yield plot^{-1}	-0.463	-0.191	0.339	0.824	0.999	0.582	0.327		0.878**	0.330**	-0.518**	0.041	-0.065
Biological yield plot^{-1}	-0.431	-0.140	0.337	0.808	0.939	0.618	0.297	0.990		-0.149*	-0.594**	0.075	0.089
Harvest index	-0.061	-0.272	-0.144	-0.116	0.402	-0.433	0.157	-0.380	-0.321		0.113	-0.084	-0.042
Reaction to MYMV	0.302	-0.009	-0.340	-0.567	-0.690	-0.469	-0.195	-0.644	-0.669	0.323		-0.090	-0.119
Zinc content	0.087	0.205	-0.011	0.102	0.024	0.305	0.099	0.048	0.078	-0.314	-0.211		0.413**
Iron content	-0.072	0.008	-0.135	0.151	0.029	0.340	-0.092	-0.072	0.092	-0.116	-0.131	0.462	

* Significant at p= 0.05; ** Significant at p= 0.01; MYMV- Mungbean Yellow Mosaic Virus

Above diagonal- phenotypic correlation coefficients; Below diagonal- genotypic correlation coefficients

Table 3: Path coefficients matrix of seed yield under untreated environment

	Days to 50% flowering	Days to maturity	Plant height	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	100-seed weight	Biological yield plot^{-1}	Harvest index	Reaction to MYMV	Zinc content (mg/kg seed)	Iron content (mg/kg seed)
Days to 50% flowering	**0.0153**	0.0103	0.0045	-0.0057	-0.0056	-0.0012	-0.0078	-0.0048	-0.0065	0.0073	0.0011	-0.0001
Days to maturity	0.0033	**0.0049**	0.0023	-0.0009	-0.0004	-0.0003	-0.0022	-0.0001	-0.0026	0.0009	0.0010	0.0000
Plant height	-0.0067	-0.0106	**-0.0225**	-0.0056	-0.0114	-0.0069	0.0057	-0.0102	0.0005	0.0079	0.0036	0.0072
No. of branches plant^{-1}	0.0087	0.0043	-0.0057	**-0.0230**	-0.0204	-0.0156	-0.0052	-0.0184	-0.0100	0.0167	-0.0014	-0.0010
No. of pods plant^{-1}	-0.0345	-0.0076	0.0478	0.0836	**0.0942**	0.0667	0.0217	0.0940	0.0487	-0.0802	-0.0059	-0.0154
No. of seeds pod^{-1}	0.0031	0.0020	-0.0117	-0.0261	-0.0272	**-0.0384**	0.0065	-0.0205	-0.0130	0.0187	-0.0040	-0.0113
100-seed wt.	-0.0120	-0.0105	-0.0060	0.0053	0.0054	-0.0040	**0.0234**	0.0083	0.0013	-0.0098	0.0030	-0.0017
Biological yield plot^{-1}	-0.3084	-0.0218	0.4457	0.7845	0.9813	0.5258	0.3490	**0.9828**	-0.0217	-0.7744	0.0277	-0.1339
Harvest index	-0.1067	-0.1340	-0.0057	0.1087	0.1295	0.0847	0.0140	-0.0055	**0.2502**	-0.0996	0.0280	-0.0296
Reaction to MYMV	0.0297	0.0112	-0.0217	-0.0450	-0.0528	-0.0301	-0.0260	-0.0488	-0.0247	**0.0620**	-0.0046	0.0054
Zinc content	-0.0006	-0.0018	0.0014	-0.0006	0.0006	-0.0010	-0.0012	-0.0003	-0.0010	0.0007	**-0.0092**	-0.0031
Iron content	-0.0003	0.0001	-0.0100	0.0014	-0.0051	0.0091	-0.0023	-0.0042	-0.0037	0.0027	0.0105	**0.0311**
Seed yield plot^{-1}	-0.320**	-0.380**	0.311**	0.665**	0.769**	0.396**	0.271**	0.840**	0.446**	-0.655**	0.033	-0.056

** Significant at p= 0.01

Table 4: Path coefficients matrix of seed yield under treated environment

	Days to 50% flowering	Days to maturity	Plant height	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	100-seed weight	Biological yield plot^{-1}	Harvest index	Reaction to MYMV	Zinc content (mg/kg seed)	Iron content (mg/kg seed)
Days to 50% flowering	**-0.0176**	-0.0109	-0.0031	0.0058	0.0064	0.0032	0.0097	0.0076	0.0011	-0.0053	-0.0014	0.0012
Days to maturity	-0.0027	**-0.0044**	-0.0017	0.0009	0.0005	0.0005	0.0022	0.0006	0.0012	0.0000	-0.0009	0.0000
Plant height	0.0010	0.0024	**0.0060**	0.0016	0.0029	0.0008	-0.0019	0.0020	-0.0006	-0.0019	-0.0001	-0.0008
No. of branches plant^{-1}	0.0011	0.0006	-0.0008	**-0.0032**	-0.0026	-0.0019	-0.0005	-0.0026	0.0004	0.0018	-0.0003	-0.0005
No. of pods plant^{-1}	0.0058	0.0018	-0.0076	-0.0130	**-0.0159**	-0.0096	-0.0020	-0.0149	-0.0016	0.0110	-0.0004	-0.0005
No. of seeds pod^{-1}	-0.0022	-0.0015	0.0017	0.0074	0.0075	**0.0124**	-0.0011	0.0077	-0.0054	-0.0058	0.0038	0.0042
100-seed wt.	0.0114	0.0106	0.0067	-0.0032	-0.0026	0.0019	**-0.0208**	-0.0062	-0.0033	0.0041	-0.0020	0.0017
Biological yield plot^{-1}	-0.4537	-0.1474	0.3545	0.8502	0.9890	0.6506	0.3126	**1.0529**	-0.3380	-0.7047	0.0823	0.0966
Harvest index	-0.0103	-0.0460	-0.0176	-0.0197	0.0172	-0.0732	0.0265	-0.0543	**0.1690**	0.0547	-0.0531	-0.0197
Reaction to MYMV	0.0013	0.0000	-0.0013	-0.0024	-0.0029	-0.0019	-0.0008	-0.0028	0.0013	**0.0041**	-0.0009	-0.0005
Zinc content	0.0016	0.0040	-0.0002	0.0020	0.0005	0.0060	0.0019	0.0015	-0.0061	-0.0041	**0.0195**	0.0090
Iron content	0.0012	-0.0001	0.0025	-0.0028	-0.0005	-0.0062	0.0015	-0.0017	0.0021	0.0024	-0.0085	**-0.0184**
Seed yield plot^{-1}	-0.360**	-0.143**	0.227**	0.652**	0.781**	0.352**	0.247**	0.878**	0.330**	-0.518**	0.041	-0.065

** Significant at p= 0.01

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