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ASSOCIATION BETWEEN SEED VIGOUR PARAMETERS AND GRAIN YIELD IN SPRING MAIZE (*ZEA MAYS* L.) UNDER NORMAL SOWN CONDITIONS

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SUMMARY

The field experiment was conducted at CCS HAU Regional Research Station, Karnal using 20 maize hybrids and 40 maize inbred lines sown with two replications during *spring* 2021-22 conditions. Analysis of seed vigour parameters was carried out at laboratory of department Seed Science and Technology, CCS HAU, Hisar. Seed vigour parameters namely standard germination (SG) (%), seedling length (SL) (cm), seedling dry weight (SDW) (g), 100- seed grain weight (HGW) (g), seedling vigour index I (SVI) and seedling vigour index II (SVII) and grain yield per plot (GY/P) (g) were analyzed. Analysis of variance revealed significant variations among the genotypes for different traits under study. In inbred lines sixteen genotypes showed >90% of standard germination (SG) and only three genotypes reported <80% SG. Whereas, in case of hybrids out of 20 genotypes only one showed >90% SG, fourteen genotypes reported 85-90% and only five genotypes reported SG between 80-85 %. All the traits showed high heritability with high genetic advance (%) except grain yield per plot which showed moderately high heritability with moderate genetic advance (%). Correlation analysis revealed the positive and significant association among all the seed vigour parameters. Path analysis coefficient revealed positive direct effect of SG, SDW, SVI and HGW with grain yield per plot.

Key words: Spring maize, seed vigour, grain yield

Maize (*Zea mays* L.) is an imperative food crop all over the world. It is also renowned as "king of crops and queen of cereals". It is an emerging future cereal crop both in developed and developing countries due to its high genetic yield potential, wider adaptability to the environmental conditions and multipurpose utilities. In India, it can be grown in all three seasons namely *Rabi, Kharif* and *Spring.* Timely sown *spring* maize crop has very high yield potential *i.e.,* 10 tonne/ha and thus can boost the farmer's income. Physiological deterioration of the seeds begins before the harvesting of seed and continues during harvesting, processing and storage of the seeds. Thus, seed lots with higher germination percentage varies in their physiological age and so does in seed vigor (Sivritepe *et al.,* 2016 and ISTA, 1995). Estimation of field stand, ability and performance of the genotypes can be done by studying the seed vigour parameters. Good quality seeds can lead to the establishment of vigorous seedlings (Adebisi *et al.,* 2013). Knowledge on the extent and pattern of genetic variability is prerequisite for generating superior varieties for maize improvement. Extent of relationship between the traits can be determined by using the correlation and path coefficient analysis. Correlation defines the strength of interdependency between the variables and phenotypic correlation is the observed association among the phenotypic values. The higher the magnitude of correlation coefficient among the traits, stronger will be their association means increase or decrease in value of one traits will ultimately increases or decrease the value of other traits. Path analysis partitions the correlation coefficient into direct and indirect effects of independent variables over the dependent variable (Devasree *et al.,* 2020 and Dewey & Lu, 1959). It is more informative than the correlation coefficient because it accurately tell the contribution of an independent variable on a dependent variable. Thus, present study was therefore aimed to evaluate to evaluate genetic variability, heritability, genetic advance as per cent of mean, the correlation coefficient analysis and path coefficient analysis among the seed vigour parameters and grain yield per plot of spring maize genotypes.

MATERIALS AND METHODS

A field experiment was conducted in CCS HAU Regional Research Station, Uchhani, Karnal during *Spring*, 2021 using seed material of sixty genetically diverse maize genotypes out of which twenty genotypes were of hybrids and rest forty were inbreds (released and pipeline inbreds). Seed vigour parameters were estimated in the laboratory of Department Seed science and Technology, CCSHAU, Hisar. Seed vigour potential was estimated by studying six parameters namely standard germination (SG) (%), seedling length (SL) (cm), seedling dry weight (SDW) (g), hundred seed grain weight (HGW), seedling vigour index I (SV I)and seedling vigour index II (SV II) and grain yield per plot (GY/P).

Standard germination test was conducted using "Between the paper (BP)" method and final count for standard germination of maize seedlings was recorded on 7th day of germination. Data for seedling length and seedling dry weight were observed by taking mean values of randomly selected ten germinated seedlings from each genotypes. The seedling vigour indices was calculated as per the method given by Abdul Baki and Aderson (1973):

Seedling vigour index I = Standard germination (%) × Average seedling length (cm) and

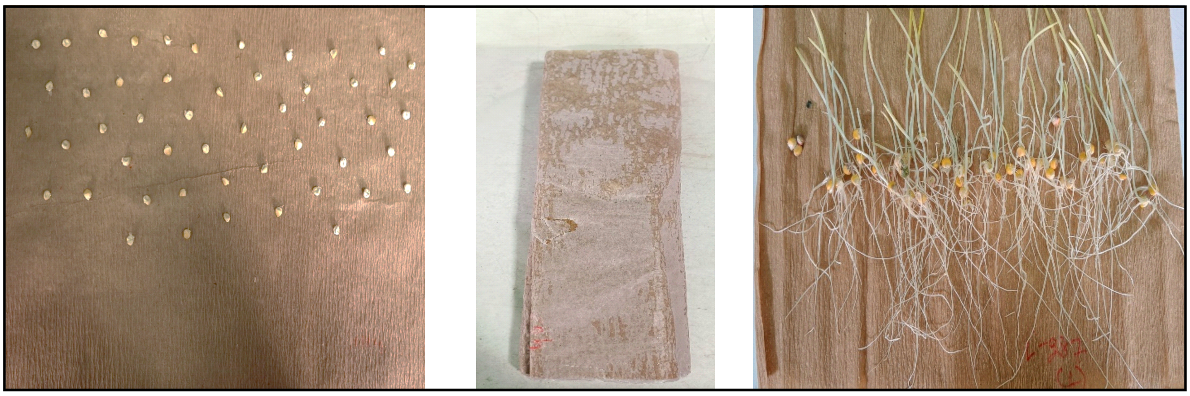
Seedling Vigour Index II = Standard germination (%) × Average seedling dry weight (g).

Statistical analysis involving ANOVA, correlation (Al-jibouri *et al.,* 1958) and path analysis (Dewey and Lu, 1959) was conducted using OP STAT Software.

RESULTS AND DISCUSSION

Variability Analysis : The Mean Sum of Squares (MSS) for various attributes is exhibited in ANOVA Table 2. The MSS values of genotypes were observed to be exceedingly significant for all the seed vigour parameters considered and grain yield per plot, indicating the satisfactory variability present among them. The consequences of mean, range, GCV, PCV, heritability and genetic advance as percent of mean for all characters are introduced in Table 3. The highest values for PCV and GCV was reported by seedling vigour index II and hundred grain weight. The values of PCV was slightly higher than GCV indicating less environmental influence on the expression of these traits. All the seed vigour parameters are showing high heritability with high genetic advance per cent of mean (%) values indicating selection of genotypes on the basis of these traits will be effective whereas, grain yield per plot reported moderately high heritability with moderate genetic advance means selection of genotypes on the basis of grain yield per plot alone may be less effective.

Genotype Characterisation : In case of inbred lines genotypes showing highest germination percentage (>90%) are HKI 1654-15-ER-1-1-1-Wink11, HKI 1040-7, HKI 1040-4, KHI 1105 and HKI 1015-6. Highest seedling vigour index I was reported in the genotype HKI 1657, HKI 1558-4, HKI 1654-15-ER-1-1-1-Wink11 and HKI 1040-7 and seedling vigour index II was reported in case of HKI 1654, HKI 1657, HKI 1378 and HKI 1654-15-ER-1-1-1-Wink11. These genotypes with highest values for standard germination, SVI and SVII also performed well under field conditions and reported high grain yield per plot values. All the hybrids considered under study showed >80% standard germination, among them hybrid developed by crossing HKI 1040 x HKI 659-3 reported highest 92.5 % standard germination percentage, highest seedling vigour index I and II and



(a) Placing of seeds on towel paper (b) folding of towel paper (c) germinated seedling on 7th day

TABLE 1
List of forty Inbreds and twenty Hybrids of Spring maize used in present investigation

S. No.	Inbreds	S. No.	Inbreds	S. No.	Inbreds
1.	HKI 139	21.	HKI 1040-7	1.	HKI 139 x HKI 1344
2.	HKI MBR 139	22.	HKI 1041	2.	HKIC 448 x HKI 1354-2
3.	HKI 161	23.	HKI 1041-2	3.	HKI 659-3x HKI 193-2
4.	HKI 163	24.	HKI 1105	4.	HKI 193-2 x L287
5.	HKI 164-7-2	25.	HKI 1128	5.	HQPM 1
6.	HKI 164-7-4	26.	HKI 1344	6.	HQPM 4
7.	HKI 193-1	27.	HKI 1354-2	7.	HQPM 5
8.	HKI 193-2	28.	HKI 1354-7	8.	HQPM 7
9.	HKI L287	29.	HKI 1378	9.	HKI 1041 x HKI 193-1
10.	HKI 288-2	30.	HKI 1558-4	10.	HKI 488T x HKI 659-3
11.	HKI 295	31.	HKI 1654	11.	HKI 1040-7 x HKI 659-3
12.	HKI 323	32.	HKI 1657	12.	HKI 163 x HKI 1664
13.	HKI 327 T	33.	HKI 1664	13.	HKI 1128 x HKI 1669
14.	HKI 488T	34.	1654-15-ER-1-1-1-Wink11	14.	HKI 1354-7 x 1344
15.	HKI 659-3	35.	LM 13	15.	HKI 295 x HKI L 287
16.	HKI 766WG	36.	LM 14	16.	HKI 1040-7 x HKI L287
17.	HKI 1011	37.	LM 15	17.	HM 6
18.	HKI 1015-6	38.	LM 16	18.	HM 8
19.	HKI 1025	39.	LM 17	19.	HKI 288-2 x LM 17
20.	HKI 1040-4	40.	DQL 2300	20.	HKI 288-2 x HKI 323

(a) Abnormal Seedling **(b) Normal Seedlings**

TABLE 2
Analysis of variance (ANOVA) for different seed vigour parameters and grain yield per plot

Source of Variation	Degree of freedom	Mean Sum of squares						
		SG	SL	SDW	SVI	SVII	HGW	GY/P
Replication	1	1.408	0.00	0.001	1,051	5.366	0.430	18,668.58
Genotype	59	61.083**	32.83**	0.009**	364,187.8**	93.175**	46.432**	2888343.4**
Error	59	197.092	0.682	0.00	1.000	1.741	0.787	1605

Standard germination (SG), seedling length (SL), seedling dry weight (SDW), 100 seed weight (HSW), Seedling vigour index I (SV I) Seedling vigour index II (SV II) and grain yield per plot (GY/P).

TABLE 3

Estimates of mean performance, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance (GA) as per cent of mean in 60 genotypes of *Spring* maize for seed vigour parameters

Traits	Mean	Range		PCV	GCV	h^2 (bs)	GA (5%)
		Minimum	Maximum				
SG	87.19	73	99.5	06.509	06.163	89.63	12.019
SL	26.27	15	38.55	15.404	15.080	95.83	30.411
SDW	0.360	0.26	0.604	18.570	18.238	96.45	36.898
SVI	2,299.5	1267.3	3585.1	18.777	18.334	95.33	36.877
SVII	31.53	20.81	53.152	21.848	21.443	96.33	43.356
HGW	21.73	10	30.46797	22.359	21.983	96.66	44.524
GY/P	1578.56	496.4	3759.445	10.29	12.79	62.09	16.36

Standard germination (SG), seedling length (SL), seedling dry weight (SDW), 100 seed weight (HSW), Seedling vigour index I (SV I) and Seedling vigour index II (SV II).

third highest grain yield per plot value. Thus, high vigour seeds are necessary to ensure satisfactory field performance of maize (Golezani *et al.,* 2014).

Correlation analysis : Correlation between seed vigour parameters is presented in Table 1. Correlation is a measure of association between the variables. The change in magnitude of one variable is associated with the change in magnitude of another variable. Table 4 of correlation coefficient values clearly reveals that there is positive significant correlation among all the seed vigour parameters observed in present investigation. All the parameter such as standard germination (0.260**), seedling length (0.305**), seedling dry weight (0.235**), seed vigour index I (0.326**) and seedling vigour index II (0.271**) was found to be in positive and significant association with the hundred grain weight. And Hundred grain weight was found to be significantly positively correlated with grain yield per plot. This clearly indicates that the genotype having more hundred grain weight may have high seed vigour and could have high germination percentage under field conditions also. Almost similar results were obtained by Wen *et al.* (2018) for 100 seed weight and seedling dry weight, Ali and Ahsan (2015) for 100 seed weight and grain yield per plant, Sivritepe *et al.* (2016) for standard germination, Adebisi *et al.* (2014) for standard germination, seedling length, seedling vigour index II and 100 seed weight and Kiran *et al.* (2021) for standard germination, seedling length, seedling dry weight, seedling vigour index I and II for wheat.

TABLE 4

Phenotypic correlation coefficients among seed vigour parameters of spring maize crop

	SG	SL	SDW	SVI	SVII	GY/P
SG	1					
SL	0.378**	1				
SDW	0.347**	0.616**	1			
SVI	0.657**	0.945**	0.626**	1		
SVII	0.594**	0.637**	0.960**	0.730**	1	
HGW	0.260**	0.305**	0.235**	0.326**	0.271**	1
GY/P	0.053NS	-0.067NS	-0.266**	-0.086NS	-0.253**	0.666**

Standard germination (SG), seedling length (SL), seedling dry weight (SDW), 100 seed weight (HSW), Seedling vigour index I (SV I) Seedling vigour index II (SV II) and grain yield per plot (GY/P).

Path analysis : The outcome of path coefficient analysis *i.e.,* direct and indirect effect of seed vigour parameters on hundred grain weight are presented in Table 5. Correlation coefficient is partitioned into its components *i.e.,* direct and indirect effect during the path analysis. It draws a clear-cut picture of the degree and direction of association among the traits. The parameters namely standard germination, seedling dry weight, seedling vigour index

TABLE 5

Direct (diagonal) and indirect (off-diagonal) effects of seed vigour parameters of spring maize crop

	SG	SL	SDW	SVI	SVII	HGW	GY/P
SG	0.3143	-0.2660	0.5790	0.5474	-1.4329	0.2053	0.053
SL	0.1188	-0.7038	1.0270	0.7870	-1.5358	0.2401	-0.067
SDW	0.1092	-0.4337	1.6664	0.5218	-2.3155	0.1853	-0.266
SVI	0.2065	-0.6648	1.0437	0.8331	-1.7614	0.2572	0.988
SVII	0.1866	-0.4480	1.5992	0.6082	-2.4128	0.2134	-0.253
HGW	0.0818	-0.2143	0.3918	0.2718	-0.6532	0.7883	0.666

Standard germination (SG), seedling length (SL), seedling dry weight (SDW), 100 seed weight (HSW), Seedling vigour index I (SV I) and Seedling vigour index II (SV II) and Grain yield per plot (GY/P).

I and hundred grain weight, showed positive direct effect on grain yield per plot.

Similar results were obtained by Deavasree *et al.,* 2020 (100 seed weight), Kiran *et al.,* 2021 (standard germination, seedling length, seedling dry weight, seedling vigour index I and II for wheat) and Patil *et al.,* 2014 (seedling vigour indices, seedling dry weight and standard germination).

CONCLUSION

Study of seed vigour parameters is essential to find out the genotypes that are more vigorous than others and correlation and path analysis is conducted to find out the parameters, on the basis of which selection can be practiced. In present study, all the parameters showed positive significant correlation with hundred grain weight which further showed highly significant positive correlation with grain yield per plot indicating seed vigour parameters increases the effectiveness of selection for high yielding genotype. Genotypes showing high values for standard germination per cent, seedling vigour index I and II under lab conditions also performed good under field conditions.

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