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Studies on genetic variability for yield attributes and nutritional composition in micronutrient efficient genotypes of wheat (*Triticum aestivum* L.)

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Abstract
The overall objective was to study the extent of genetic variation and association among grain yield and micronutrient (Zn & Fe) traits. Fifty-two germplasm of bread wheat were tested in Randomized complete block design. There was significant variability among wheat genotypes for yield as well as associated morphological and micronutrient traits which can be utilized in wheat breeding programs. The phenotypic coefficients of variation values were higher than genotypic coefficients of variation values. High PCV and GCV were recorded for number of tillers per plant, iron, grain yield per plant, flag leaf area. High heritability values were observed for iron, zinc, 1000 grain weight, grain yield per plant, plant height and days to 50 percent flowering. Among the traits iron, grain yield per plant, zinc and 1000 grain weight had high values of genetic advance as percent of mean (GAM). However, Grain yield showed positive and significant correlation with plant height, 1000 grain weight at phenotypic level. The lines with higher Zn and Fe content along trait could be dynamic components of functional food and improved food nutritional quality. The data generated in study provide useful resources for its development in wheat breeding programme.

Keywords: *Triticum aestivum*, micronutrients, grain yield, genetic variability, correlation

Introduction

The World Health Organization (WHO) estimates that over 820 million people are hungry, two billion have micronutrient deficiencies, and another two billion are obese or overweight, indicating a paradigm shift toward nutritional security (UNEP 2021). Iron (Fe) and zinc (Zn) deficiency inhibits a variety of human metabolic functions, including oxygen transport, cell growth and differentiation, DNA replication, protein synthesis, oxidative stress reduction, and brain tumour protection (Thavarajah *et al.*, 2010) [28]. During the COVID-19 pandemic, the importance of micronutrients in the formation of a well-functioning immune system was well established, and efforts to increase Zn and Fe bioavailability through dietary supplementation, food fortification, and dietary diversification have been made to reduce micronutrient malnutrition. However, the potential method for reducing global micronutrient deficiency has been anticipated through the production of staple food crop culti (McAuliffe *et al.*, 2020) [15]. The CGIAR's Harvest Plus programme was designed to address the global nutritional crisis by focusing on high-value crops. The project's main purpose is to develop nutritionally enhanced cultivars of common wheat (*Triticum aestivum* L.) to boost people's intake of zinc and iron, two micronutrients that are considered crucial for human health. The location-specific wheat breeding programmes are using advanced elite lines created through this effort. Studies on genetic diversity for Zn and Fe content in the seed, their inheritance in the plant, and their sinking into the progeny seed are required for genetic improvement toward biofortification. The International Maize and Wheat Improvement Center (CIMMYT, Int.) is leading a global effort to develop and disseminate high-yielding wheat varieties that contain high levels of grain Zn and Fe to partners in South Asia with funding from the Harvest Plus Challenge Program and the CGIAR Research Program on Agriculture for Nutrition and Health.

Wheat breeders have constantly attempted to improve wheat genotype yield potential. We are currently concentrating on enhancing productivity rather than food quality. Malnutrition affects over 67 percent of the world's population. Nearly 2 billion people worldwide, mostly in underdeveloped nations, suffer from hidden hunger caused by iron and zinc inadequacy (Velu *et al.*, 2012) [30]. In this situation, it's critical to develop new wheat genotypes with increased yield potential and high nutritional content. Only when there is sufficient genetic variability for yield and micronutrient characteristics is this possible. When there is a significant correlation between these features and micronutrient traits, indirect selection based on these traits is possible.

Material and Methods

The experimental material comprised of forty nine zinc and iron enriched Harvest plus genotypes and along with three adapted varieties *viz*., HD-3086, JAUW-683, RSP-561 were assayed for grain iron and zinc.

The experiment was conducted at the geographical location of SKUAST-Jammu, India, during *Rabi* season 2019-20 with three replications laid down randomized complete block design. In the experiment, the size of the plot was 1.0 square meters and agronomic practices followed standard practices used by the breeding program. The soil was subsequently irrigated at 21-25 days after sowing (DAS), 45-60 DAS, 60-70 DAS, 90-95 DAS, 100-105 DAS and 120-125 DAS respectively. Off this irrigation at CRI stage is most important. On full maturation, randomly five plants were selected from each genotypes for recording morph physiological and yield attributing data in march (130 DAS) involving eight economical traits *viz*., plant height, number of tillers per plant, days to 50 per cent flowering, flag leaf area (cm^2), spikelets per spike, days to maturity, 1000 grain weight (g) and grain yield per plant (g).

Zinc and Iron content (ppm)

A random sample of 20 spikes per entry was harvested after physiological maturity, the spikes were threshed in a clean cloth and the grain was separated from husk in a plastic chaaj. The grain was sampled for Zn and Fe analysis. Care was taken at every step to avoid metal contamination. The grain samples were analyzed at Grain Quality Laboratory, ICAR-IARI, New Delhi, India, using atomic absorption spectrophotometer (AAS) instrument (Datta *et al.*, 2017) [34].

Statistical analysis

The Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), Genetic advance as percentage of mean (GAM), heritability and correlation were calculated using version 4.1 package of R programme (Singh and Chaudhary) [35].

Results and Discussion

Natural variations are the most important resources for plant breeders. Development of new varieties superior to existing ones is only possible when there is significant variability for the trait of interest. As improved yield is the ultimate target of wheat, the present investigation was carried out with one of the objective to study genetic variability among wheat genotypes for yield and its attributing traits with high micronutrient (Zn & Fe) content. Analysis of variance (ANOVA) is a simple statistical technique used to study differences among means of various groups and partitioning of variability into causal components (Sawyer, 2009) [22]. Based on ANOVA, significant genetic variability was found among the fifty-two wheat genotypes of present study for all the morphological and micronutrient traits evaluated (Table 1). The significant treatment mean sum of squares for all the traits revealed that the present fifty-two genotypes of wheat are genetically diverse and can be used in further wheat breeding programs.

In the present study a general trend of higher genotypic coefficient of variation (GCV) for all traits noticed except days to maturity (Table 2). Almost all the morphological and micronutrient (Zn & Fe) traits had GCV ranging from small to medium. Fe concentration exhibited the highest GCV (27.68) followed by grain yield per plant, Zn concentration, number of tillers per plant, and flag leaf area indicating the existence of a greater amount of variability among the genotypes for these traits. Phenotypic coefficient of variation (PCV) was higher than GCV for all the traits. Similar to GCV, same trend of Phenotypic coefficient of variation was highest for number of tillers per plant (27.82) followed by Fe concentration, grain yield per plant, flag leaf area and Zn concentration, Low GCV and PCV estimates were obtained for days to maturity and days to 50 per cent flowering. The GCV and PCV results of presents study are found in line with the earlier study of Rangare *et al.*, 2010 [20]; Riaz-ud-Din *et al.*, 2010 [21]; Nukasani *et al.*, 2013 [18]; Kumar *et al.*, 2014 [13]; Arya *et al.*, 2017 [1]; Mathew *et al.*, 2018 [14]; Bayisa *et al.*, 2020 [3]. The knowledge of GCV and PCV gives an idea of genetic nature of a trait and the extent to which it can be improved (Bayisa *et al.*, 2020) [3]. The extent of GCV and PCV of a trait gives an idea of genotypic and phenotypic variability of that trait in the research material. The significant GCV and PCV of all traits for the fifty-two genotypes of present study revealed that these genotypes are genetically diverse and can be utilized in breeding programs. The proportion of phenotypic variance which can be transferred to next generation is represented by the estimate of heritability. In other words heritability gives an idea of effectiveness of selection. According to Singh (2001) [25], heritability values can be classified into very high (>80%), moderate high (60-79%), moderate (40-59%) and low (< 40%). The effect of selection can be predicated with the combined estimate of heritability and genetic advance. In most cases, the selection is applied with taking the mean as a base and thus genetic advance as percentage of mean is more important in such cases in comparison to genetic advance. It can be classified into low (0-10%), moderate (11-20%) and high (above 20%) and calculated by using genetic advance and the mean of trait (Johnson *et al.*, 1995) [11]. Grain yield per plant which is economic part of wheat had highest heritability along with high genetic advance (Table 4.3). This clearly indicated that grain yield in wheat as such cannot be improved effectively by direct selection. The present estimates of heritability and genetic advance of grain yield were found in line with the results of various earlier researchers (Meles *et al.*, 2017; Nagar, 2019; Thapa *et al.*, 2019; Bayisa *et al.*, 2020) [16, 17, 27, 3]. High heritability was recorded for Fe followed by Zn, 1000 grain weight grain yield per plant, plant height and days to 50 percent of flowering with high genetic advance a percent of mean. Similar results of high heritability estimates for Fe content were reported by Jayasudha *et al.*, 2014 [10]; Velu *et al.*, 2012 [30]; Gomez-Becerra *et al.*, 2010 [5] and Peleg *et al.*, 2009 [19]. High heritability for Zn reported by Hao *et al.*, 2014; Jayasudha *et al.*, 2014 [10]; Yashavanthkumar *et al.*, 2014 [32]; Velu *et al.*, 2012 [30]; Gomez-Becerra *et al.*, 2010 [5]; Peleg *et al.*, 2009 [19]; 1000 grain weigh, number of tillers per plant reported by Singh *et al.*, 2013 [24]; Yadav *et al.*, 2006 [31] and many other researchers have already proved the same result. Earlier studies of Joshi *et al.*, 2010 [12] reported low heritability estimates for both Zn and Fe content in wheat. High heritability estimates for Zn and Fe content were reported by Hariprasanna *et al.*, 2014 [8] and Susmita and Selvi, 2014 [26] for sorghum, Singh *et al.*, 2013 [24] for cabbage and Govindaraj *et al.*, 2011 [6] for bajra. However, Simic *et al.*, 2012 [23] reported moderate heritability estimates for grain Zn and Fe content in maize. These traits can be improved directly which in turn can be helpful in selection of high yielding with high micronutrient (Zn & Fe) content genotypes. Among physiological parameters very high heritability was found for all traits except Flag leaf area, spikelets per spike and, days to maturity and number of tiller per plant. Similar heritability and genetic advance estimates for morphological and physiological traits of wheat has been reported by earlier studies (Meles *et al.*, 2017; Nagar, 2019; Thapa *et al.*, 2020; Bayisa *et al.*, 2020) [16, 17, 27, 3]. The traits with high heritability and low genetic advance such as days to 50 percent of flowering can be improved by selection but requires more generations of selection in comparison to the traits with high genetic advance. A correlation coefficient close to one indicates high association among two traits. Further a trait associated with grain yield may have direct or indirect effect on grain yield which is measured by the technique of path analysis (Dewey and Lu, 1959). In the present experiment two morphological traits *viz*., Plant height and 1000 grain weight, were found highly significant and positively phenotypic associated with grain yield (Table 3). Fe content showed highly significant and positive correlation with grain Zinc (0.459**). Zinc content exhibited highly significant negative correlation with plant height (-0.251*), flag leaf area (-0.197*) spikelets per spike (-0.264**), The results are in accordance with the results of Graham *et al.*, 1999; Ortiz and Graham, 2000; Liu *et al.*, 2006; Oury *et al.*, 2006; Morgounov *et al.*, 2007; Peleg *et al.*, 2008; Ficco *et al.*, 2009 [4]; Zhao *et al.*, 2009 [33]; Gomez-Becerra *et al.*, 2010 [5], Hugo *et al.*, 2010 [9] and Badakhshan *et al.*, 2013 [2].

Table 1: Analysis of variance (ANOVA) for different morpho-micronutrient traits (Zn and Fe) in fifty two genotypes of wheat.

Source of Variations	DF	Mean sum of Squares									
		Plant height (cm)	Number tillers per plant	Days to 50 percent flowering	Flag leaf area (cm^2)	Spikelets per spike	Days to maturity	1000 grain weight (g)	Grain yield per plant (g)	Zinc (ppm)	Iron (ppm)
Replication	2	5.31	0.31	10.95	14.55	3.87	8.33	0.95	0.26	0.72	1.87
Treatments	51	156.98**	3.42*	19.93**	66.93**	6.08**	3.96**	45.04**	26.79**	76.06**	421.89**
Error	102	23.19	2.05	3.29	31.01	3.13	2.12	0.7	0.63	0.9	1.12

Table 2: Estimates of mean, range, GCV, PCV, heritability and genetic advance as percent of mean for yield and micronutrient traits in wheat.

Traits	General Mean	Range	GCV	PCV	h^2	Genetic advance as percent of mean
Plant height (cm)	84.48±2.78	67.66-102.33	7.90	9.74	65.8	13.21
No. of tillers per plant	5.68±0.83	3.67-9.33	11.89	27.82	18.3	10.46
Days to 50 percent flowering	99.31±1.05	94-105.33	2.37	2.99	62.8	3.87
Flag leaf area (cm^2)	29.85±3.22	20.53-42.8	11.59	21.96	27.9	12.60
Spikelets per spike	18.95±1.02	16.33-23	5.23	10.69	23.9	5.27
Days to maturity	136.65±0.84	133.67-138.67	0.57	1.21	22.4	0.59
1000 grain weight (g)	38.48±0.48	29.03-46.4	9.98	10.22	95.4	20.10
Grain yield per plant (g)	13.22±0.47	7.17-20.1	22.32	23.12	93.2	44.40
Zinc (ppm)	34.54±0.55	8-40.67	14.49	14.74	96.5	29.33
Iron (ppm)	42.78±0.61	9.67-88.33	27.68	27.79	99.2	56.79

Table 3: Genotypic and phenotypic correlation coefficient among ten morpho-physiological and micronutrient traits in wheat (*Triticum aestivum* L.).

Traits		No. of tillers per plant	Days to 50 per cent flowering	Flag leaf area (cm^2)	Spikelets per spike	Days to maturity	1000 grain weight (g)	Zinc (ppm)	Iron (ppm)	Grain yield per plant
Plant height (cm)	rg	0.276**	-0.428**	0.342**	0.081	-0.670**	0.193*	-0.282**	-0.081	0.276**
	rp	0.072	-0.288**	0.180*	0.106	-0.195*	0.166*	-0.251*	-0.07	0.211*
Number of tillers per plant	rg		-0.035	0.233*	-0.137	-0.373**	0.174*	-0.294**	-0.446**	0.297**
	rp		-0.046	-0.019	0.027	-0.079	0.083	-0.094	-0.187*	0.13
Days to 50 percent flowering	rg			0.068	0.425**	0.290**	-0.220*	-0.066	-0.300**	-0.231*
	rp			0.018	0.127	0.089	-0.186*	-0.055	-0.232*	-0.169*
Flag leaf area (cm^2)	rg				0.223*	-0.448**	0.424**	-0.383**	-0.229*	0.02
	rp				0.005	-0.055	0.219*	-0.197*	-0.116	0.01
Spikelets per spike	rg					-0.062	-0.136	-0.580**	0.389**	0.310**
	rp					0.141	-0.039	-0.264**	-0.190*	0.129
Days to maturity	rg						-0.003	-0.059	0.095	-0.087
	rp						0.014	-0.02	0.03	0.02
1000 grain weight (g)	rg							-0.073	0.095	0.169*
	rp							-0.069	0.093	0.163*
Zinc (ppm)	rg								0.469**	-0.123
	rp								0.459**	-0.125
Iron (ppm)	rg									-0.06
	rp									-0.058

Conclusion

The present study showed the presence of considerable variability among the studied wheat genotypes and the possibility of improving micronutrient (Zn & Fe) and yield characters through selection. The study also revealed the importance of considering other characters in the process of selection of genotypes for micronutrient and yield. This implied that some traits can be used as surrogate traits for indirect selection of other difficult to measure traits.

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