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Research Article

AGRONOMIC CHARACTERIZATION OF RICE GENOTYPES AND ITS RELATIONS WITH YIELD TRAIT

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Abstract- In the present study we reported the physio-morphological characterization of fourteen mineral rich as well as high yielding rice genotypes. Genotypic and phenotypic coefficient of variation for various traits in fourteen rice varieties reported in this study. Phenotypic coefficient of variation (PCV) was higher than or equal to the genotypic coefficient of variation for all the parameters of all rice genotypes. Phenotypic correlation coefficient association between various traits in fourteen rice varieties was assessed, yield per plant showed a positive correlation with grains per panicle (0.250; p=0.01), number of panicles per plant (0.111; p=0.01), and effective number of tillers per plant (0.152; p=0.01). In addition to this path coefficient analysis was done to study direct and indirect effects of component traits on grain yield per plant. The data shows that grain weight had highest positive direct effect on grain yield per plant.

Keywords- Agronomic, grain yield, mineral content.

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Introduction

Oryza is an agronomically important genus containing species with highly diverse morphology [1]. The genus *Oryza* includes cultivated rice species, *O. sativa,* which constitutes an important part of the diet of more than half of the world's population [2]. More than 90% of this cultivated rice is grown and consumed in Asia. India stands first in terms of area under rice cultivation and second in rice production after China. Kato, *et al.* [3], the pioneer for rice classification, recognized two main varietal groups, *Indica* and *Japonica* on the basis of morphological, serological characters and inter-varietal hybrid fertility parameters. In the present study we reported the physio-morphological characterization of 14 micronutrient rich rice genotypes [4] and high yielding genotypes was done and its correlation with grain yield was studied. Worldwide, rice production has more than doubled in 35-year period from 257 million tons in 1996 to 600 million tons in 2000. Rice (*Oryza sativa*) has become a model cereal for genomic research because of its small genome size (~430 million bp) and diploid nature. International Rice Research Institute (IRRI, The Philippines) and national research institutions in various countries are maintaining >200,000 germplasm accessions of rice. Rice is one of the most diverse crops being grown as far north as Manchuria (China) and far south as Uruguay and New South Wales in Australia. Moreover, micronutrient element supplementation of seeds can upturn crop yields when seeded to micronutrient deficient soils, pledging their acceptance by farmers [5]. So, it is necessary to maintain the agronomic characters along with enriched micronutrient content of the crop. The yield/plant was reported to be positively correlated with plant height and panicles/plant [6], with panicle length [7], with grains/panicle and 100 grains weight [8]. Chakrabarty, *et al.* [9] reported that yield/plant showed significant positive genotypic correlation with plan height (0.21), panicles/plant (0.27), panicle length (0.53), effective grains/panicle (0.57) and harvest index (0.86).

Materials and Methods

Plant material

The mineral rich and high yielding rice varieties were selected were collected from CCS HAU Rice Research Station, Kaul.

Raising of crop

The rice genotypes were raised during kharif season of 2008-09 at CCS HAU, Rice Research Station, Kaul (Kaithal), which falls under semi-tropical regions of North India.

Recording of the observations

Observations were recorded only for fourteen mineral-rich and high-yielding rice genotypes. From every line, six plants were randomly selected and observations were recorded on the following characters. The data was subsequently analyzed to determine the variability, correlation and path coefficient analysis.

Plant height (cm)

Height of the main culm from ground to tip of the panicle was measured in centimeters.

Effective number of tillers per plant

Fully developed panicles bearing tillers of each plant were counted at the time of maturity.

Panicle length (cm)

Length of panicle was measured in centimeters

Number of panicles per plant

The total number of panicles per plant was counted at the time of maturity.

Number of grains per panicle
Number of grains per panicle was counted manually

1000-grain weight (g)
1000-grains were counted from an individual plant by manual counting and their weight was recorded in grams.

Statistical Methods
Parameters of variability
Mean: The mean value of each character was worked out by dividing the totals by corresponding number of observation:

$$x = \frac{\Sigma Xi}{N}$$

Where, Xi - any observation in I^{th} treatment
N - Total number of observations

Standard Deviation: The positive square root of mean of squared deviations from arithmetic mean, so called root mean square deviation. The standard deviation is a measure of how widely values are dispersed from the average value (the mean). STDEV uses the following formula:

$$\sqrt{\frac{\sum (x-\bar{x})^2}{(n-1)}}$$

Where,
x- Sum of all values of the variable
x– Mean of values.
n- Sample size

Coefficient of variation: Genotypic and phenotypic coefficient of variation was estimated by the formula suggested by Burton (1952) for each character as:

$$\text{Genotypic coefficient of variation (G.C.V)} = \sqrt{\frac{\sigma^2 gii}{x}} \times 100$$

$$\text{Phenotypic coefficient of variation (P.C.V)} = \sqrt{\frac{\sigma^2 pii}{x}} \times 100$$

where 'x' is the mean of particular character.

Correlation coefficient analysis
Correlated characters are of interest for three main reasons; in connection with the genetic causes of correlation through the pleiotropic action of genes, to know how selection for one character will cause simultaneous change in other characters and to determine relationship between character and fitness.
Phenotypic 'r(P) and genotypic 'r(g)' correlation coefficients for all possible pairs of thirteen characters were calculated from the variance and covariance's was estimated by $r(g)= \sigma x y (g)/[\sigma x (g) X \sigma y (g)]$
Where,
$\sigma x y (g)$ = Genotypic covariance between characters x and y
$\sigma^2 x (g)$ = Genotypic variance of character x
$\sigma^2 y (g)$ = Genotypic variance of character y
The phenotypic correlation was measured by:

$$r(P)= \sigma x y (P)/[\sigma x (P) X \sigma y (P)]$$

Where,
$\sigma x y (P)$ = Phenotypic covariance between characters x and y
$\sigma^2 x (P)$ = Phenotypic variance of character x
$\sigma^2 y (P)$ = Phenotypic variance of character y
The phenotypic correlation coefficients were tested against standardized tabulated significant value of r with (n-2) degree of freedom as per the procedure by Fisher and Yates (1963).

Path-coefficient analysis
The genotypic correlation coefficients were used to work out path coefficient analysis. Path coefficient matrix was obtained according to Dewey and Lu (1959). A set of simultaneous equations in the following form were solved:

$$r_{ny} = P_{ny} + r_{n2} P_{2y} + r_{n3} P_{3y} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots r_{nx} P_{xy}$$

Where,
r_{ny} = Correlation coefficient of one character and yield
P_{ny} = Path coefficient between the character and yield
r_{n2} r_{n3}.... r_{nx} = represent correlation coefficient between that character and each of other yield components in turn.
The following correlation matrics were formed.

Matrix A	Matrix B
r_{1y}	1 r_{12} r_{13}.....r_{1n}
r_{2y}	1 r_{23}.....r_{2n}
r_{3y}	1.....r_{3n}
r_{ny}	1

Path coefficients P_{jy} were obtained as follows: $P_{jy} = (B^{-1}) \times A$
The indirect effects for a particular character through other characters were obtained by multiplication of direct Path and particular correlation coefficient between those characters, respectively.

$$\text{Indirect effect} = r_{ij} \times P_{jy}$$

Where, i = 1.....n
j = 1.....n
$P_{jy} = P_{1y} P_{2y}$.....P_{ny}
r_{ij}= Correlation between two independent characters.
The residual factors i.e. the variation in yield unaccounted for those associated was calculated from the following formulae:

$$\text{Residual factor (x)} = 1 - R2$$

Where, R2 = P1y r1y + P2y r2y + ...Pny rny
R2, is squared multiple correlation coefficients and is the amount of variation in yield that can be accounted for by the yield component character.

Results
The data on various agronomic traits of fourteen rice varieties conventionally grown in field at RRS Kaul is given in [Table-1].

Plant height (cm)
The average plant height of fourteen rice varieties varied between 82.25 cm to 156.33 cm [Table-1]. Basmati 370 (156.33 cm) and Taraori Basmati (155 cm) had greater plant height as compared to the *Indica*, mineral-rich *Indica* and *Japonica* rice varieties. PAU201 (88.0 cm), HKR47 (98.8 cm), IR36 (93.16 cm), Palman 579 (97.66 cm) and NPTII (82.25 cm) rice varieties recorded lower plant heights. Cross-bred Pusa Basmati 1 (119.50 cm) and some mineral (iron and zinc) rich varieties such as Jaya (104.33 cm), BR4-10 (116.83 cm), and HKR 95-157 (117.6 cm) had intermediate (semi-dwarf) plant height.

Number of panicles per plant
The average number of panicles in fourteen rice varieties varied from 14 to 27 [Table-1]. *Indica* rice varieties recorded relatively higher number of panicles/plant as compared to mineral-rich *Indica*, *Japonica* and Basmati rice varieties. PAU201 (27 panicles per plant) had highest number of panicles/plant followed by Basmati 370 (26) and Taraori Basmati (26). In comparison, mineral (iron and zinc) rich rice varieties such as Jaya (14), Palman 579 (16), HKR95-157 (17), and TNG67 (15) has relatively lower number of panicles/plant. Pusa Basmati 1 (21) and *Japonica* rice variety, Azucena (22) had the intermediate number of panicles/plant.

Panicle length (cm)
The average length of panicle varied between 21.16 cm to 27.66 cm [Table-1]. HKR47 (27.66 cm) and CSR10 (26.83 cm) *Indica* rice varieties had higher panicle plant length as compared to the mineral rich rice varieties such as HKR95-157 (21

cm), TNG67 (22.50 cm) and BR4-10 (21.16). Some of the mineral-rich (iron and zinc) rice varieties such as Jaya (25.33 cm), Palman 579 (24.55 cm), Pusa Basmati 1 (24.33 cm) recorded moderate panicle length.

Effective number of tillers

Average effective number of tillers per plant varied from 14 to 27 (PAU201) [Table-1]. *Indica* rice varieties (PAU201, Basmati 370 and Taraori Basmati) had higher effective number of tillers compared to other rice varieties.

Number of grains per panicle

The average number of grains per panicle varied between 80 (HKR95-157) to 255 (PAU201), respectively [Table-1]. HKR95-157 (80), Palman 579 (96), Taraori Basmati (81), and Basmati 370 (82) rice varieties recorded relatively lower number of grains/panicle. HKR47 (136), CSR10 (137), Jaya (110), IR36 (153) and Pusa Basmati 1 (135) recorded a moderate number of grains per panicle.

Table-1 *Summary of mean±S.E, C.D, C.V, range, phenotypic and genotypic coefficient of variation for agronomic traits in fourteen rice genotypes grown in the field at Rice Research Station, Kaul*

Variety	Plant Height (cm)	Panicle/ Plant	Panicle Length (cm)	Effective no. of Tillers	Grain /Panicle	Yield/ Plant (g)	1000 Grain Weight (g)
PAU201	88.00±2.63	27±0.44	24.33±0.21	27±0.44	255±0.30	27.18±0.10	28.98±0.14
HKR47	98.8±1.00	24±0.33	27.66±0.21	24±0.33	136±0.30	24.26±0.07	27.12±0.09
IR36	93.16±0.87	18±0.40	24.66±0.33	18±0.40	153±0.80	22.89±0.11	25.17±0.079
CSR10	105.00±0.73	24±0.50	26.83±0.47	24±0.50	137±0.40	24.40±0.13	24.67±0.041
Jaya	104.33±0.80	14±0.47	25.33±0.21	14±0.47	110±0.34	20.15±0.06	21.19±0.056
BR4-10	116.83±0.60	25±0.30	21.16±0.40	25±0.30	80±0.42	22.36±0.12	24.50±0.12
HKR95-157	117.6±0.47	17±0.61	21.00±0.44	17±0.61	80±0.33	18.20±0.16	28.04±0.15
Palman579	97.66±1.76	16±0.44	24.50±0.22	16±0.94	96±1.05	17.35±0.13	18.82±0.13
Taraori Basmati	155.00±2.23	26±0.55	25.00±0.44	26±0.55	81±0.34	22.18±0.08	25.29±0.066
Pusa Basmati 1	119.50±2.46	21±0.22	24.33±0.21	21±0.22	135±0.21	21±0.01	22.61±0.01
Basmati 370	156.33±2.33	26±0.51	25.83±0.47	27±0.51	82±0.36	21.18±0.08	25.57±0.12
TNG67	140.41±0.88	15±0.40	22.50±0.22	15±0.40	127±0.44	22.33±0.06	22.33±0.06
Azucena	141.41±0.61	22±0.40	22.33±0.42	22±0.40	126±0.40	21.28±0.13	22.24±0.08
NPTII	82.25±0.17	24±0.40	21.83±0.30	24±0.40	118±0.88	26.76±0.28	26.76±0.28
C.D.	3.81	1.40	0.97	1.40	1.54	0.35	0.35
SE(m)	1.34	0.49	0.34	0.49	0.54	0.12	0.12
SE(d)	1.90	0.70	0.48	0.70	0.77	0.17	0.17
C.V.	2.71	5.62	3.49	5.62	1.0	1.32	1.24
Range	82-157	14-27	21-28	14-27	80-255	17-27	18-29
GCV	21.18	21.30	8.42	21.573	35.37	11.57	12.42
PCV	21.35	22.03	9.12	22.22	35.38	11.64	12.49
F cal	4.1688**	0.8441**	1.239**	0.5702**	0.2669**	1.2660**	0.0371**

** Significant at 0.01%

Yield per plant (g)

The average yield per plant of fourteen rice varieties varied between 17.35 g (Palman579) to 27.18 g (PAU201) [Table-1]. PAU201 (27.18 g) and NPTII (26.76 g) rice varieties recorded the highest grain yield per plant. Palman 579 (17.35 g), HKR95-157 (18.20 g), Jaya (20.15 g), and Pusa Basmati 1 (21 g) rice varieties recorded relatively lower grain yield per plant. Taraori Basmati (22.18 g), HKR47 (24.26 g), and CSR10 (24.40) have the moderate grain yield per plant.

1000 seeds weight (g)

The average 1000 seed weight varied between 18.82 (Palman 579) to 28.98 g (PAU201) [Table-1]. PAU201 (28.98 g), HKR95-157 (28.04 g), and HKR47 (27.12 g) rice varieties recorded higher 1000 grain weight compared to other rice varieties such as Palman 579 (18.82 g), Jaya (21.19 g) and Pusa Basmati 1 (22.61 g). BR4-10 (24.50 g), Taraori Basmati (25.29 g) and Basmati 370 (25.57 g) rice genotypes had the moderate 1000 grain weight.

Analysis of variance

One way ANOVA analysis showed significant (P≤ 0.001%) variability for all the agronomic traits as shown in [Table-1]. The genotypic variance for all the characters was higher than the error variance suggesting that variability was more due to genetic factors than caused by the environment.

Genotypic and phenotypic coefficient of variation

The summary of mean ± SE, range, CD, CV, GCV and PCV for various traits in fourteen rice varieties is given in [Table-1]. Phenotypic coefficient of variation (PCV) was higher than or equal to the genotypic coefficient of variation for all the parameters of fourteen rice genotypes used in this study. These genotypes exhibited highest PCV and GCV estimates for number of grains per panicle (35.37, 35.38) followed by grain yield per plant (21.57, 22.22) and effective number of tillers per plant (21.30, 22.03) *Indica*ting that greater amount of variability prevailed for these traits in these genotypes.

Correlation coefficient analysis

Phenotypic correlation coefficient analysis was carried to assess the association between various traits in fourteen rice varieties [Table-2]. In these genotypes, yield per plant showed a positive correlation with grains per panicle (0.250; p=0.01), number of panicles per plant (0.111; p=0.01), and effective number of tillers per plant (0.152; p=0.01). Plant height showed a negative correlation with yield per plant (-0.209; p=0.01) and grains per panicle (-0.521; p=0.01). Number of grains per panicle showed a positive correlation with panicle length (0.282; p=0.01), and number of panicles per plant (0.516; p=0.01). Number of effective tillers per plant showed positive correlation with plant height (0.083; p=0.01), panicle length (0.283; p=0.01) and number of panicles per plant (0.750; p=0.05).

Path coefficient analysis

Path coefficient analysis was done to assess direct and indirect effects [Fig-1] of component traits on grain yield per plant in 14 rice genotypes [Table-3]. The diagonal values in [Table-3] represent the direct effect. The data shows that grain

weight (0.937) had highest positive direct effect on grain yield per plant, followed by grains per panicle (0.250), and tillers per plant (-0.154) and panicle length (-0.030) had negative effects on positive grain yield.

Table-2 *Phenotypic correlation coefficient between various phenotypic and grain quality traits in 14 rice varieties*

	Plant Height (cm)	Panicle /Plant	Panicle Length (cm)	Effective number of Tiller/ Plant	Grain /Panicle	Yield /Plant (g)	1000 Grain Weight (g)
Plant Height (cm)	1						
Panicle /Plant	0.387	1					
Panicle Length (cm)	0.349	0.189	1				
Effective number of Tiller/ Plant	0.083	0.750**	0.283	1			
Grain /Panicle	-0.521	0.516	0.282	0.412	1		
Yield/Plant (g)	-0.209	0.111	0.028	0.152	0.250	1	
1000 Grain Weight (g)	0.256	0.159	0.096	0.255	0.266	0.936**	1

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

Table-3 *Assessment of direct (diagonal) and indirect effects of component traits on grain yield in fourteen rice varieties by path coefficient analysis*

	Plant Height (cm)	Panicle /Plant	Panicle Length (cm)	Effective number of Tiller/Plant	Grain /Panicle	1000 Grain Weight (g)	"r' with grain Yield/ Plant
Plant Height (cm)	0.008	0.003	0.002	0.001	-0.004	-0.002	0.201
Panicle/Plant	0.029	0.074	0.014	0.055	0.038	0.011	0.112
Panicle Length (cm)	-0.045	-0.024	0.126	-0.036	0.036	0.012	-0.030
Effective number of Tiller/ Plant	0.008	0.071	-0.026	0.095	0.039	0.024	-0.154
Grain/Panicle	-0.025	0.025	0.014	0.020	0.048	0.012	0.250
1000 Grain Weight (g)	0.250	0.155	0.093	0.249	0.259	0.972	0.937

Residual effect = 0.318 r = Correlation

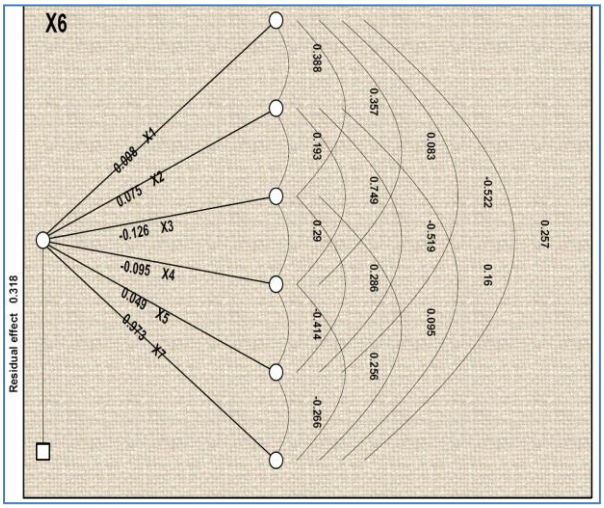

Fig-1 Assessment of direct (diagonal) and indirect effects of component traits on grain yield in fourteen rice varieties by path coefficient analysis (X1- Plant height, X2- Panicle/plant, X3- Panicle length, X4- Tillers/plant, X5- Grain/plant, X6- Yield/plant, X7- 1000 Grain/wt.).

Discussion

The present study showed that micronutrient (Fe, Zn) rich genotypes-Palman 579, HKR95-157, Taraori Basmati, BR4-10, TNG67, Jaya and CSR10; selected after screening the 220 rice genotypes [4] and improved/ high-yielding rice varieties (HKR47, PAU201, Pusa Basmati 1, IR36 and NPTII) showed significant variation for agronomic traits (plant height, number of panicles per plant, panicle length, effective number of tillers, number of grains per panicle, yield per plant and 1000 seed weight), *Indica*ting greater diversity among these fourteen rice varieties. Micronutrient rich genotypes, Palman 579 (17.35 g) and HKR95-157 (18.20 g), were quite low yielding compared to the commercially cultivated *Indica* rice varieties such as PAU 201 (27.18 g), HKR 47 (24.26 g), and CSR 10 (24.40 g). This is not unexpected as these micronutrient–rich varieties have not bred for yield and yield components.

The study also showed that the genetic coefficient of variation (GCV) for different traits occupied major extent of phenotypic coefficients of variation (PCV) *Indica*ting more of genetic variance and less environmental variance. These rice genotypes exhibited highest PCV and GCV estimates for number of grains per panicle followed by yield per plant, number of panicles per plant and effective number of tillers per plant *Indica*ting that greater amount of variability prevailed for these traits in these genotypes. Similar results were reported by Kaul and Kumar [10-12]. Number of tillers/plant had low heritability estimate. During assessing genetic variability in 88 genotypes reported high genotypic variance for kernel elongation ratio followed by biological yield per plant and grain yield per plant [13].

In this study, correlation between various traits was worked out to assess their association at genotypic as well as phenotypic levels. In most cases, magnitude of the correlation coefficient at genotypic level was higher than inherent association between different traits. In fourteen rice genotypes, yield per plant had positive correlation with number of grains per panicle, number of panicles per plant and effective number of tillers per plant and negative correlation with panicle length. Plant height had a negative correlation with grain/panicle. Strongest positive correlations have been reported between grain yield and panicles per plant, grains per panicle and spikelets per panicle [14]. The number of grains per panicle also had a strong positive correlation with percent seed set, panicle length, and days to heading. It has been reported a significant correlation of grain yield with number of effective tillers per plant, 1000 grain weight, number of grains per panicle and panicle length [15]. Positive correlations were found between plant height and panicle length. There was a small negative correlation between grains per panicle and grain weight and between panicle length and days to heading [14]. The DNA profiling of 14 rice genotype using 48 microsatellite markers [16-18].

Path coefficient analysis provides a clear and more realistic picture of a complex situation that exists at the correlation level. It measures direct as well as indirect effects of one variable on the dependent variable through the other traits. Partitioning of genotypic correlation between yield per plant and its component characters *Indica*ted that the direct effects were in general of higher magnitude than that of indirect effects for most of the characters. The result of path coefficient analysis revealed that 1000 grain weight, number of grains per panicle and number of panicles per plant had highest positive direct effect on grain yield per plant. Grain yield per plant has also been reported earlier to be positively correlated with plant height and panicles per plant [6], panicle length [7], grains per panicle and 100-grain weight [8]. Negative genotypic correlations between grain yield per plant and panicle length [19] and harvest index [20] have also been observed. Significant positive genotypic correlation has been reported between yield per plant and plant height (0.21), panicles per plant (0.27), panicle length (0.53), effective grains per panicle (0.57) and harvest index (0.86), but significant negative correlation with 100 seed weight (-0.35) [9,17,21-24]. Phenotypic correlations between seed yield/plant and other characters showed similar trend

like genotypic correlations. Harvest index exhibited significant positive genotypic correlation with plant height (0.30), panicles/plant (0.43), panicle length (0.30) and effective grains per panicle (0.53) in addition to seed yield per plant. Effective grains/panicle revealed significant positive genotypic correlation with plant height (0.32), panicle length (0.89) and 100 grain weight (0.35) in addition to yield/plant.

Conclusion

The present study showed that micronutrient (Fe and Zn) rich genotypes (Palman 579, HKR95-157, Taraori Basmati, BR4-10, TNG67, Jaya and CSR10; selected after screening the 220 rice genotypes) and improved/ high-yielding rice varieties (HKR47, PAU201, Pusa Basmati 1, IR36 and *NPTII*) showed significant variation for agronomic traits (plant height, number of panicles per plant, panicle length, effective number of tillers, number of grains per panicle, yield per plant and 1000 seed weight), *Indica*ting greater diversity among these fourteen rice varieties. The genetic coefficient of variation (GCV) for different traits occupied major extent of phenotypic coefficients of variation (PCV) *Indica*ting more of genetic variance and less environmental variance. Yield per plant had positive correlation with number of grains per panicle, number of panicles per plant and effective number of tillers per plant and negative correlation with panicle length. Plant height had a negative correlation with grain/panicle. Path coefficient analysis revealed that 1000 grain weight; number of grains per panicle, effective number of tillers per plant and number of panicles per plant had highest positive direct effect on grain yield per plant.

Application of research: It helps in improving crop yield resulting in economic beneficiaries or farmers. It also helps in improving micronutrient and grain yield traits quality**.**

Research Category: Agronomic, grain yield, mineral content

Abbreviations:

PCV: Phenotypic coefficients of variation
GCV: Genetic coefficient of variation

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