Estimation of genetic variability parameters and correlation coefficients for grain yield characters of rice (*Oryza sativa* L.)

ABSTRACT

Twenty-six rice genotypes were examined, and an experiment was carried out by using a Randomized Block Design with three replications at the Department of Genetics and Plant breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini Allahabad, U.P during the kharif season of 2022. The analysis of variance revealed significant differences between genotypes for all 13 characters, showing that there is a wide scope for selecting traditional rice varieties for yield and its components from the current gene pool. WGL-915 (43.05g) had the highest grain production per hill among the 26 genotypes, followed by JGL-21078 (36.99g), WGL-283 (32.60g), WGL-13400 (28.51g), WGL-14377 (28.25g), and WGL-347 (27.76g). When compared to the check genotype NDR-359, all of these genotypes produced significantly higher yields (22.67g). High estimates of heritability and genetic advance as a percentage of mean were observed for test weight, number of spikelets per panicle, biological yield, and grain production per hill. These qualities are governed by additive gene effects and have the best chance of improvement via simple selection. The length of the flag leaf, the length of the panicle, the biological yield, the harvest index, and the test weight all had positive and very significant correlation associations with grain production per hill. The selection of these features will thus be effective in increasing rice grain yield.

Keywords: Rice, Variability, Heritability, Genetic advance, Correlation

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the Poaceae family Graminae genus *Oryza* and is a genuine diploid with chromosome number 2n =2x= 24. Rice has been farmed by humans for over 10,000 years. *Orzya sativa* cultivars are classified into three subspecies: indica, japonica, and javanica. Whereas indica variants are grown across the tropical and subtropical regions, japonica types are grown throughout the temperate zone, and javanica varieties are grown mostly in Indonesia.

Rice has an essential part in the Indian economy because it is a staple food for two-third of the country's population. Rice contains 80% carbohydrates, 7-8% protein (the amino acid profile shows that it is rich in glutamic acid and aspartic acid, highest quality cereal protein being rich in lysine (3.8%), 3 % fat, 3% fibre, iron 1mg, and zinc 0.5 mg **(Prabha *et al.*, 2018).** Rice is a short-day autogamous crop.

Rice is grown on 165.25 million hectares worldwide, with an annual production of 503.27 million metric tonnes (United states Department of Agriculture, 2022). India is the world's second largest rice producer, after China. Rice is grown on 46.38 million hectares in India, with an average yield of 2809kg/ha and a production of 130.29 million tonnes **(Agriculture Statistics at a Glance, 2022)**.

Rice is the most important crop in Uttar Pradesh, with around 5.7 million acres under cultivation. Cropping intensity is at 153 percent. Rice output in the state ranks second in the country. The state's productivity is at 2.68t/ha, implying that there is an urgent need to increase rice productivity in Uttar Pradesh, which can only be accomplished by developing high yielding hybrid varieties (Agriculture Statistics at a Glance, 2022) India's current population is 140 cores; by 2025, it will be approximately 150 cores. As a result, high producing cultivars are required.

The most significant factor for rice cooking and eating quality is its amylose content. Many of the properties of rice starch are affected by amylose content, volume expansion, and water absorption. Cooking time is critical since it greatly influences the tenderness and stickiness of cooked rice. Because rice contains more water and solid ingredients, the energy content per unit volume or weight of cooked rice decreases as the imbibition ratio rises. Working-class people still consider high-volume culinary expansion to be of greater quality, regardless of whether it is longitudinal or transverse. City dwellers, on the other hand, prefer types that are longer than they are wide. Export quality rice can be characterised as fine rice**. (Dipti *et al*.,2002).**

According to **Robinson *et al*., (1949),** heritability is the key concern for breeders since it implies that progress can be obtained through selection. Heritability combined with genetic progress would produce the predicted genetic advantage through selection **(Johnson *et al.*, 1955).**

Any breeding effort for high yield and quality requires knowledge of the nature and magnitude of variability contained in existing material, as well as the relationships between the various traits. Grain yield, a complex character, is impacted not only by its associated qualities, which are controlled by a number of genes, but also by environmental factors. To make selection successful, genetic variability must be separated from total variability, allowing breeders to implement appropriate breeding programmes. Because yield is associated with its component characters, mere variability studies will not be of much help in improving yield; it is essential to know the degree of mutual association (correlation) prevailing between yield and its component characters, which forms the basis for selecting the best yield.

Estimates of the correlation between yield and other plant parameters are useful in identifying desired plant features for planning an effective breeding programme. The correlation coefficient quantifies the degree of association as well as the genetic or non-genetic relationship between two or more features used for selection.

Regarding these we conducted research by following objectives.

1. To estimate genetic variability, heritability and genetic advance for grain yield charactersamong selected rice genotypes
2. To estimate the correlation coefficient between yield and yield contributing characters of rice genotypes
3. To study about cooking quality of rice genotypes

MATERIALS AND METHODS

The present investigation was made to understand the genetic variability, heritability, genetic advance & correlation in rice. The details of the materials used and the methods adopted in the investigation, which was carried out at Department of Genetics and Plant breeding, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini during the *kharif* season of 2022.

Total 26 rice genotypes were grown under irrigated circumstances using Randomized Block Design with three replications for each genotype. Data for thirteen quantitative variables and twelve culinary quality traits were collected on five randomly selected plants from each genotype in each replication.

On the basis of five competitive plants selected at random from each replication, replication-specific data were collected for the following thirteen (13) quantitative traits:1) Days to 50% flowering, 2) Days to maturity, 3) Flag leaf length, 4) Flag leaf width, 5) Plant height, 6) Number of total tillers per hill 7) Number of Productive Tillers, 8) Panicle length, 9) Number of spikelets/ Grains per panicle, 10) Test weight, 11) Harvest index, 12) Biomass, 13) Grain yield per plant.

Cooking Quality traits:

1.Hulling percentage 2. Length/breadth ratio 3. Grain type, 4. Kernel length before cooking (mm), 5. Kernel length after cooking (mm), 6. Kernel width before cooking (mm), 7. Kernel width after cooking (mm), 8. Kernel elongation ratio, 9. Head rice recovery, 10. Gel consistency, 11. Alkali spreading value, 12. Amylose content.

The F-test was created to evaluate variance analysis for genetic differences. Using the method described by **Panse and Sukhatme (1967),** total variance was separated into variation caused by treatments and variation caused by replications. Furthermore, measures of heritability (in the broad sense), genetic progress as a percentage of mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), and correlation analysis were done using the appropriate statistical approach.

The software called "OP-STAT" was used to perform the analysis mentioned above.

Experimental material:

The experimental material for present investigation were comprised of 25 rice genotypes and 1 check variety. Rice genotypes were received from Professor Jayashankar Telangana State

Agricultural University, Rajendranagar, Hyderabad and check variety received from Department of Genetics and Plant Breeding, SHUATS during *kharif*-2022.

Chart 1: List of genotypes studied in the experiment.

S.No.	Genotypes	S.No.	Genotypes	S.No.	Genotypes
1	MTU-1010	11	WGL-32100	21	JGL-18047
2	RNR-10754	12	WGL-347	22	JGL-1798
3	RNR-15048	13	WGL-44	23	JGL-384
4	RDR-355	14	WGL-283	24	JGL-11727
5	RDR-8702	15	WGL-14377	25	JGL-21078
6	RDR-763	16	WGL-13400	26	NDR-359 (**CHECK**)
7	RDR-7555	17	WGL-20471		
8	BPT-5204	18	KNM-118		
9	WGL-14	19	KNM-733		
10	WGL-915	20	KNM-1638		

Statistical analysis

The research data is subjected to made analysis based on the following categories. It gives the information about the amount of variation that exists among the germplasms.

1. Analysis of variance **(Fisher, 1935)**
2. Coefficient of variation **(Burton and De vane, 1952)**
   a. Genotypic coefficient of variation **(GCV)**
   b. Phenotypic coefficient of variation **(PCV)**
3. Heritability broad sense **(Burton and Devane, 1953)**
4. Genetic advance **(Johnson *et al.*, 1955)**
5. Correlation coefficient analysis **(Al Jibouri *et al.*, 1958)**

RESULTS AND DISCUSSION

The analysis of variance Table-1 showed that all 13 quantitative characters under examination demonstrated significant differences using the treatment, or mean sum of squares due to genotype, at the 1% level of significance. This shows that there is plenty of room in the current gene pool for traditional rice types to be chosen for yield and its components. Large amounts of diversity may exist as a result of the materials used, which came from various sources, as well as environmental factors that affect the phenotypes.

On the basis of mean performance grain yield per hill ranged from 9.61g to 43.04g with grand mean of 23.99g. High grain yield per hill is a highly desirable character and maximum grain yield per hill was observed in WGL-915(43.05g) followed by JGL-21078(36.99g) and WGL-13400(28.51g). Whereas low grain yield per hill was observed in RNR-15048(9.61g) followed by WGL-14(15.08g) and BPT-5204(17.62g). Based on above results concluded that, the genotype WGL-915 is best for grain yield per hill.

Coefficient of variation: The results (table 2) revealed that the magnitude of PCV was higher than the corresponding GCV for all the traits indicating that there was an influence of the environment. Among the 13 quantitative characters, high estimates of GCV and PCV (>20%) were recorded for test weight (29.20, 30.16), grain yield (27.24, 29.58), number of spikelets per panicle (24.27, 25.52) and biological yield (23.96, 25.69). Moderate estimates of GCV and PCV (10-20%) were recorded for harvest index (18.24, 20.20), number of tillers per hill (17.48, 19.49), number of panicles per hill (16.11, 19.44), flag leaf length (14.77, 17.07), panicle length (11.40, 12.92) and days to 50% flowering (10.66, 12.56). Low estimates of GCV and PCV (0-10%) were recorded for flag leaf width (8.61, 11.34), plant height (7.98, 11.50) and days to maturity (6.41, 9.90).

Heritability: The estimates of heritability ranged from 41.98 % to 93.75 % (Table 2). High heritability (>60%) was recorded for test weight (93.75%), number of spikelets per panicle (90.43%), biological yield (86.96%), grain yield (84.82%), harvest index (81.53%), number of tillers per hill (80.48%), panicle length (77.87%), flag leaf length (74.92%), days to 50% flowering (72.02%) and number of panicles per hill (68.68%). Moderate heritability (30-60%) was recorded for flag leaf width (57.68 %), plant height (48.21%) and days to maturity (41.98%). There is no evidence of low heritability in these characters. The high heritability values of the considered traits in the present study indicated that these were less influenced by the environment and thus help in effective selection of the traits based on the phenotypic expression by adopting simple selection method and suggested the scope of genetic improvement.

Genetic advance as percent of mean:

The estimates of genetic progress expressed as a percentage of the mean (table 2) ranged from 8.56 to 58.24. Test weight (58.24), grain yield (51.68), number of spikelets per panicle (47.55), biological yield (46.02), harvest index (33.93), number of tillers per hill (32.30), number of panicles per hill (27.50), flag leaf length (26.34), and panicle length (20.73) all showed high genetic advance as a percent of mean (>20%). Days to 50% flowering (18.63), flag leaf width (13.47), and plant height (11.42) all showed moderate genetic advancement (10–20%). In days to maturity (8.56), little genetic advance as a percent of mean (0–10%) was noted.

Genotypic Correlation Coefficient

In the present investigation from table 3, grain yield per hill showed the positive and highly significant genotypic association with plant height (0.409**), flag leaf length (0.403**), panicle length (0.516**), biological yield (0.707**), harvest index (0.462**) and test weight (0.558**). The correlation shows positive non-significant association with flag leaf width (0.090), number of tillers per hill (0.211) and number of panicles per hill (0.197). The correlation shows negative non- significant association with days to 50% flowering (-0.149) and days to maturity (-0.090).

Similar results were reported earlier by **Prasad *et al*. (2017)**, the results showed that panicle weight, the number of productive tillers per plant, the number of filled grains per panicle, and the weight of 1000-grains were found to be more significant factors in rice productivity.

Phenotypic Correlation Coefficient

Grain yield per hill (table 4) exhibits positive significant correlation with plant height (0.421**), flag leaf length (0.412**), panicle length (0.515**). Biological yield (0.705**), harvest index (0.464**) and test weight (0.560**). The correlation shows positive non-significant association with flag leaf width (0.095), number of tillers per hill (0.206), numberof panicles per hill (0.194) and number of spikelets per panicle (0.203). The correlation coefficient showed negative non-significant association with days to 50% flowering (-0.152) and days to maturity (-0.092).

Similar results were reported earlier by **Mishu *et al*. (2016)** *i.e.,* grain yield per yield has positive significant correlation with days to maturity, spikelet length and 1000- grain weight and negative correlation with plant height and non-significant correlation with other characters. **Pratap *et al*. (2018)** observed that grain yield per plant exhibited strong positive association with spikelet fertility percentage, filled grain per panicle, effective tiller per plant, plant height and test weight and significant positivecorrelation with plant height, effective tillers per plant, test weight, filled grains per panicle and spikelet fertility.

Cooking Quality:

Among 25 genotypes (Table-5) NDR-359 had high kernel length before and after cooking, WGL-347 had high kernel elongation ratio, WGL-20471 had high L/B ratio, BPT-5204 had high hulling percentage and head rice recovery, WGL-32100 showed better gel consistency, RDR-763 showed better alkali spreading value and JGL-384 showed better amylose content.

CONCLUSION

From the present investigation it is concluded that analysis of variance showed significant variation to all the characters, among 26 genotypes. WGL-915 was found superior for grain yield per hill. High to moderate estimates of GCV, PCV, high heritability coupled with high genetic advance as percent mean was recorded for test weight, grain yield per hill, number of spikelets per panicle and biological yield. At both genotypic and phenotypic levels plant height, flag leaf length, panicle length, biological yield, harvest index and test weight are highly significant and positively correlated with grain yield per hill. An increase in any one of these or all quantitative characters would bring simultaneous increase in the yield. Hence utmost importance should be given to these characters during selection for grain yield improvement.

Figure-1 Bar diagram depicting GCV, PCV, heritability and genetic advance for 13 quantitative characters of rice.

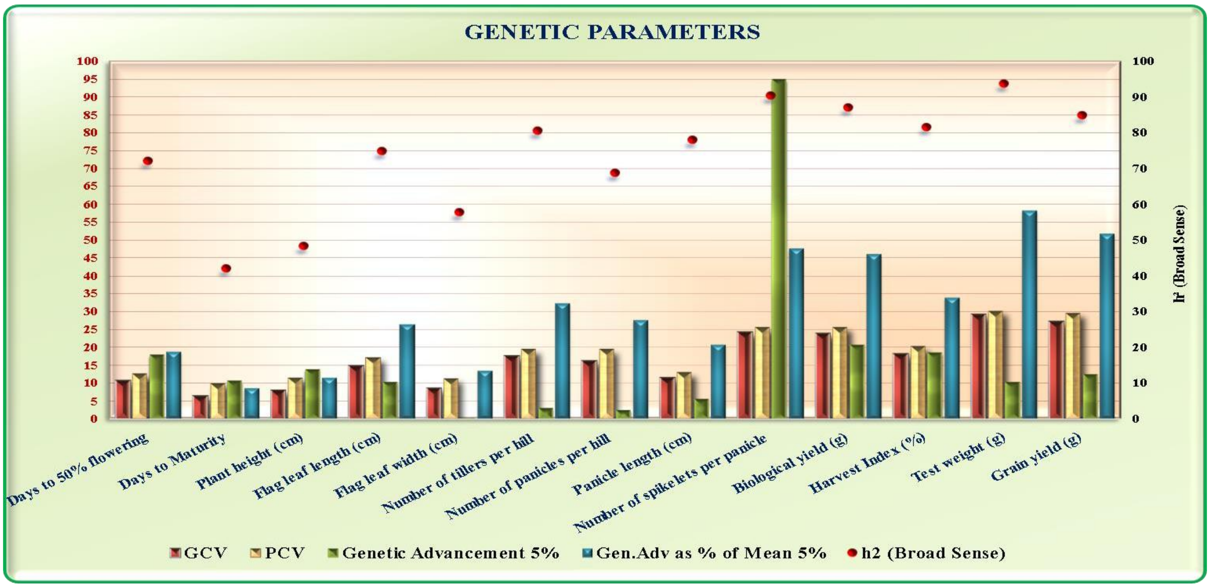

Table 1: Analysis of Variances for 13 quantitative traits among rice genotypes

Trait	Mean sum of squares		
	Treatment	Replication	Error
Degree of Freedom	**25**	**2**	50
Days to 50% flowering	353.366**	88.1920	40.512
Days to maturity	276.015**	108.7050	87.052
Plant height	383.554**	197.4240	101.139
Flag leaf length	112.552**	27.4890	11.299
Flag leaf width	0.029**	0.0020	0.006
Number of tillers per hill	8.68**	0.740	0.649
Number of panicles per hill	7.115**	0.3160	0.939
Panicle length	29.736**	1.2640	2.573
Number of spikelets per panicle	7290.671**	589.0620	248.415
Biological yield	365.499**	28.9960	17.399
Harvest index	317.346**	11.5580	22.282
Test weight	80.513**	2.3430	1.75
Grain yield per hill	135.742**	13.70	7.644

Table 2: Genetic parameters for 13 quantitative characters in rice genotypes

Trait	GCV%	PCV%	h^2	Genetic advance	GA% of Mean
Days to 50% flowering	10.655	12.555	72.021	17.853	18.627
Days to maturity	6.413	9.898	41.981	10.593	8.56
Plant height	7.983	11.497	48.207	13.877	11.418
Flag leaf length	14.774	17.069	74.918	10.359	26.343
Flag leaf width	8.611	11.337	57.681	0.139	13.472
Number of tillers per hill	17.48	19.485	80.482	3.024	32.304
Number of panicles per hill	16.107	19.437	68.675	2.449	27.497
Panicle length	11.401	12.919	77.871	5.47	20.725
Number of spikelets per panicle	24.272	25.524	90.43	9.491	47.548
Biological yield	23.956	25.69	86.96	20.693	46.02
Harvest index	18.24	20.2	81.529	18.447	33.927
Test weight	29.198	30.155	93.752	10.22	58.239
Grain yield per hill	27.243	29.581	84.817	12.397	51.684

GCV: Genotypic Coefficient of Variation**, PCV:** Phenotypic Coefficient of Variation**, h^2:** Heritability**,**
GA% of Mean: Genetic Advance at percent of mean

Table 3: Estimates of Genotypic correlation coefficient between grain yield and its component traits in rice

Traits	Days to fifty percent flowering	Days to maturity	Plant height	Flag leaf length	Flag leaf width	Number of tillers per hill	Number of panicles per hill	Panicle length	Number of spikelets per panicle	Biological yield	Harvest Index	Test weight	Grain yield per hill
Days to fifty percent flowering	1	0.812**	0.194	-0.199	0.347*	-0.159	-0.162	-0.058	0.303*	0.140	-0.419**	-0.299**	-0.149
Days to maturity		1	0.145	-0.224*	0.245*	-0.128	-0.152	-0.042	0.183	0.095	-0.310*	-0.239**	-0.090
Plant height			1	0.380**	0.340*	-0.106	-0.091	0.579**	0.136	0.591**	-0.121	0.258*	0.409**
Flag leaf length				1	0.085	-0.189	-0.167	0.644**	0.313*	0.479**	-0.041	0.150	0.403**
Flag leaf width					1	-0.546**	-0.515**	-0.022	0.262*	0.194	-0.129	-0.198	0.090
Panicle length						1	0.961**	0.057	-0.165	0.124	0.108	0.262*	0.211
Number of total tillers per hill							1	0.028	-0.187	0.122	0.097	0.263*	0.197
Number of panicles								1	0.103	0.626**	-0.060	0.387**	0.516**
Number of spikelets per panicle									1	0.366**	-0.181	-0.423**	0.204
Biological yield										1	-0.220	0.406**	0.707**
Harvest Index											1	0.334*	0.462**
Test weight												1	0.558**
Grain yield per hill													1

****1% Level of Significance**

***5% Level of Significance**

Traits	Days to fifty percent flowering	Days to maturity	Plant height	Flag leaf length	Flag leaf width	Number of tillers per hill	Number of panicles per hill	Panicle length	Number of spikelets per panicle	Biological yield	Harvest Index	Test weight	Grain yield per hill
Days to fifty percent flowering	1	0.809**	0.180	-0.187	0.357*	-0.158	-0.163	-0.061	0.397*	0.139	-0.429**	-0.308**	-0.152
Days to maturity		1	0.128	-0.211	0.254*	-0.126	-0.153	-0.045	0.175	0.094	-0.320*	-0.248**	-0.092
Plant height			1	0.402**	0.348*	-0.099	-0.088	0.588**	0.129	0.604**	-0.130	0.255*	0.421**
Flag leaf length				1	0.078	-0.190	-0.166	0.654**	0.326*	0.489**	-0.036	0.157	0.412**
Flag leaf width					1	-0.546**	-0.514**	-0.019	0.268*	0.199	-0.127	-0.196	0.095
Panicle length						1	0.961**	0.054	-0.167	0.120	0.110	0.263*	0.206
Number of total tillers per hill							1	0.026	-0.189	0.118	0.098	0.264*	0.194
Number of panicles								1	0.100	0.625**	-0.061	0.387**	0.515**
Number of spikelets per panicle									1	0.365*	-0.186	-0.428**	0.203
Biological yield										1	-0.222	0.406**	0.705**
Harvest Index											1	0.332*	0.464**
Test weight												1	0.560**
Grain yield per hill													1

Table 4: Estimates of Phenotypic correlation coefficient between grain yield and its component traits in rice

****1% Level of Significance**

***5% Level of Significance**

Table-5 Mean performance of rice genotypes for twelve qualitative traits evaluated during *kharif*-2022

Sl. No.	Genotypes	Hulling percentage	L/B ratio	Grain type	Kernal length before cooking	Kernal length after cooking	Kernal width before cooking	Kernal width after cooking	Kernel elongation ratio	Head rice recovery	Gel consistency	Alkali spreading value	Amylose content
1	MTU-1010	68.45	3.92	Long slender	6.23	6.66	1.59	2.24	1.07	58.20	70.00	4	23.38
2	RNR-10754	69.90	3.55	Long slender	6.46	6.89	1.82	2.35	1.07	63.20	40.00	4	23.57
3	RNR-15048	64.85	3.45	Short slender	5.62	6.27	1.63	2.26	1.12	57.90	22.00	5	20.72
4	RDR-355	62.50	3.87	Long slender	6.61	7.05	1.71	2.59	1.07	53.18	44.33	4	25.94
5	RDR-8702	70.70	3.04	Long slender	6.62	7.11	2.18	2.54	1.07	59.25	40.00	4	23.70
6	RDR-763	71.00	3.54	Short slender	5.45	6.75	1.54	2.17	1.24	63.37	46.00	6	21.10
7	RDR-7555	81.35	1.88	Short bold	5.03	5.81	2.67	2.89	1.16	70.58	44.00	5	18.76
8	BPT-5204	85.35	3.52	Short slender	5.17	7.08	1.47	2.81	1.37	72.00	25.00	4	24.61
9	WGL-14	81.70	3.68	Short slender	5.34	6.40	1.45	2.34	1.20	67.60	22.00	4	24.99
10	WGL-915	74.40	3.93	Long slender	7.16	8.31	1.82	2.21	1.16	64.92	67.00	5	23.80
11	WGL-32100	69.20	3.76	Short slender	5.53	6.49	1.47	2.14	1.17	59.81	86.00	1	20.55
12	WGL-347	72.65	3.74	Short slender	5.31	7.51	1.42	2.61	1.41	66.78	45.00	4	23.82
13	WGL-44	73.55	3.93	Short slender	5.43	6.62	1.38	2.72	1.22	64.52	64.00	4	23.60
14	WGL-283	76.20	4.01	Long slender	6.61	7.22	1.65	2.26	1.09	68.04	55.67	6	23.70
15	WGL-14377	67.85	3.87	Long slender	6.39	7.46	1.65	2.16	1.17	59.86	54.33	4	23.11
16	WGL-13400	75.55	3.79	Long slender	6.78	8.43	1.79	2.72	1.24	65.17	59.51	5	22.51
17	WGL-20471	58.55	4.25	Long slender	6.85	7.29	1.61	2.62	1.06	52.73	56.20	6	23.18

18	KNM-118	76.60	4.20	Long slender	6.63	7.58	1.58	2.47	1.14	66.38	38.33	4	21.45
19	KNM-733	69.20	4.04	Short slender	5.62	7.22	1.39	2.73	1.28	59.80	39.00	5	23.30
20	KNM-1638	46.30	3.86	Short slender	5.71	6.54	1.48	2.18	1.15	43.00	22.00	5	21.47
21	JGL-18047	73.35	4.04	Long slender	6.54	7.94	1.62	2.74	1.21	66.12	63.67	4	23.37
22	JGL-1798	76.70	3.78	Short slender	5.37	6.41	1.42	2.63	1.19	59.45	68.25	2	21.65
23	JGL-384	71.45	4.03	Short slender	5.72	7.61	1.42	2.63	1.33	56.45	67.85	4.5	29.90
24	JGL-11727	63.90	3.99	Long slender	6.02	7.07	1.51	2.47	1.17	54.67	66.33	5	25.94
25	JGL-21078	75.85	3.95	Long slender	6.44	7.94	1.63	2.58	1.23	62.73	41.00	4	26.30
26	NDR-359(check)	92.00	3.05	Long slender	7.17	9.63	2.23	3.60	1.34	52.50	41.00	4	27.01

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