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RESEARCH ARTICLE

SELECTION OF UPLAND RICE LINES TO GRAIN YIELD AND DISEASES TOLERANCE

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ABSTRACT

Bacterial and fungal diseases directly affect rice yield and quality, and the simplest and, often, the most cost effective management for diseases is planting resistant varieties. The aim of this study was to evaluate thirteen elite lines from the Brazilian Upland Rice Breeding Program for grain yield and tolerance to leaf blast, neck blast, grain discoloration, and leaf scald diseases, in order to select superior genotypes with potential to turn into new cultivars adapted to the upland crop system. The experiments were carried out in two environments considering the randomized block design with two replicates. The means for each trait were grouped according to the Scott-Knott approach, and it was obtained the Pearson correlation of diseases grades with grain yield. Lines showed significant differences for all traits, except for leaf scald resistance. All diseases showed negative correlation with grain yield, meaning that the occurrence of these diseases resulted in losses in lines productivity. Despite the incidence of diseases, nine of the thirteen lines showed grain yield above the national mean in 2015. However, lines CMG1509 and CMG1896 showed a bad performance for grain discoloration, what can be a limitation to its acceptance in the market. The lines with best performance for both grain yield and tolerance to the diseases considered were CMG1511, CMG2085, CMG2089, CMG1977, and CMG2170, indicating potential to be new upland rice cultivars.

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INTRODUCTION

Rice (*Oriza sativa* L.) is grown and consumed in all continents, turning to be one of the most important crops in many development countries, feeding about half of the worlds population. Around the world, rice is grown in 160 million hectares, producing close to 700 million of tons. Brazil appears with an area of 2.33 million hectares, and a production of approximately 12.4 million tons, mostly of irrigated rice (CONAB, 2015). Nevertheless, many regions with great productive and market potential in Brazil are not farmed due to the absence of rice cultivars best suited to specific environments. In this sense, upland rice plays a strategic role enabling rice cropping in regions where is not possible to flood. No different from other crops, rice yield and quality are directly affected by bacterial and fungal diseases.

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The main diseases reported in rice are blast, scald, grain discoloration, brown spot, tungro, and others, causing significant losses to the farmer. There are multiple strategies to copy with this problem, as using pesticides, program the better time and place to plant, not over apply fertilizer, etc. However, planting a resistant variety is the simplest and, often, the most cost effective management for diseases (IRRI, 2016). The main problems of the occurrence of diseases in rice fields are reducing yield and deteriorate grain quality. Therefore, the aim of this study was to evaluate the grain yield and the tolerance of rice lines to leaf blast, neck blast, grain discoloration, and leaf scald diseases, in order to select superior genotypes with potential to turn into new cultivars adapted to the upland crop system.

MATERIALS AND METHODS

The experiment was carried out in the 2013/2014 and 2014/2015 growing seasons at the experimental field of the

Agriculture Department of UFLA in Lavras, Minas Gerais, Brazil (21º14'43"S, 44º59'59"W) accounting two environments. Thirteen lines from the Upland Rice Breeding Program from the Brazilian research institutions UFLA, EMBRAPA and EPAMIG were evaluated for grain yield (GY), and for resistance to diseases leaf blast (LB) and neck blast (NB), caused by the fungus *Pyricularia grisea*; grain discoloration (GD), caused by a complex of multiple fungus and bacteria; and leaf scald (LS), caused by the fungus *Microdochium orizae*. All diseases were evaluated using a grading scale from 1 to 9, which 1 means no symptom and 9 means that all plot showed severe symptoms. The experimental design was a randomized block with two replicates, plots consisting of three rows of 4 m spaced 35 cm with 80 seeds per meter. All cultivation practices necessary for the development of the crop were performed according to the technical recommendation for the environment, except that no fungicide was used because disease tolerance was part of the evaluation. Individual and joint analyses of variance were performed using the statistical software R (R Development Core Team, 2012), and the means grouped according to the Scott-Knott approach (Scott and Knott, 1974) with 5% of probability. It was also obtained the Pearson correlation of diseases grades with grain yield.

RESULTS AND DISCUSSION

Highly significant differences ($p \leq 0.05$) between lines were detected in the analysis of variance for grain yield (GY), leaf blast resistance (LB), neck blast resistance (NB), and grain discoloration resistance (GD) in the 2013/2014 growing season, and for LB, NB, and GD in the 2014/2015 growing season. In the joint analysis of variance, lines showed significant differences for all traits, except for leaf scald resistance (LS), indicating that there is variability between lines for almost all traits (not shown). Environments were significantly different for all traits, except for LB, suggesting that environments influenced on the expression of these traits. Significant genotype x environment interaction was observed only for NB and GD, meaning that lines performance varied across environments (not showed).

Table 1. Averages grain yield (GY), and for resistance to diseases leaf blast (LB) and neck blast (NB), caused by the fungus *Pyricularia grisea*; grain discoloration (GD), caused by a complex of multiple fungus and bacteria; and leaf scald (LS), caused by the fungus *Microdochium orizae*, obtained from VCU/Lavras test in 2013/2014 and 2014/2015 crop

Lines	LS	LB	NB	GD	GY (kg/ha)
CMG 1509	2,17a	2,00a	2,33a	4,00b	6998,41a
CMG 1511	2,50a	1,67a	2,00a	2,67a	6831,69a
CMG 2085	2,50a	1,33a	1,50a	2,83a	6678,64a
CMG 1896	2,33a	2,50a	2,67a	3,33b	6613,41a
CMG 2089	2,67a	1,67a	2,00a	3,00a	6381,71a
CMG 1977	2,50a	2,67a	2,67a	2,83a	6202,52a
CMG 2170	2,50a	1,83a	2,33a	2,67a	6173,07a
BRSMG Caçula	2,50a	4,67b	5,17c	2,33a	6069,94a
BRSMG Relâmpago	2,50a	4,33b	4,5b	2,83a	5694,74a
CMG 2097	2,50a	1,67a	2,80a	3,33b	5197,54b
CMG 1987	3,17a	2,50a	2,67a	3,50b	4822,44b
BRS Esmeralda	2,67a	2,33a	4,00b	3,50b	4546,13b
BRSMG Caravera	3,00a	4,00b	6,00c	3,17b	3782,53b

Means followed by the same letter in the column do not differ with a probability of 5% by the Scott-Knott approach.

All analyses sowed accuracies estimates higher than 0.70, except for LS, indicating good experimental precision, according to the classification of Resende and Duarte (2007). It is important to note that low accuracy estimates are related to non-significant F test, when the F value is quite low. In this study, lines did not show variability for LS, justifying the low accuracy showed in the analyses for this trait. Similar results were found by Silva (2013) in evaluating the reaction of common bean lines to white mold disease. Grain yield mean varied from 6998.41 Kg. ha^{-1} (line CMG1509) to 3782.53 $Kg.ha^{-1}$ (line Caravera). For diseases grades, means varied from 1.33 (line CMG2085) to 4.67 (line BRSMG Caçula) for LB; from 1.50 (line CMG2085) to 6.00 (line BRSMG Caravera) for NB; from 2.33 (line BRSMG Caçula) to 4.00 (line CMG1509) for GD; and form 2.17 (line CMG1509) to 3.17 (line CMG1987) for LS (Table 1). Line BRS Caravera showed the lowest grain yield and the higher damage caused for NB. Neck blast is one of the diseases that mostly direct affects rice productivity (IRRI, 2016). Since NB occurs in the panicle, yield losses in affected plants are very high. Blast can occur in areas with frequent and prolonged periods of rain shower and large day-night temperature difference. Tropical countries commonly present theses environmental conditions, and the most efficient and economical management in this case is to use resistant lines.

All diseases showed negative correlation with grain yield, meaning that the occurrence of these diseases resulted in losses in lines productivity. Neck blast showed an expressive correlation with grain yield, r = -0.67, confirming its important effect in reducing rice productivity. However, the disease that showed the highest correlation with grain yield was leaf scald, r = -0.76. Leaf blast and grain discoloration showed correlations with GY of lower magnitude, r = -0.39 and r = -0.20, simultaneously. Despite the incidence of diseases, all lines showed grain yield above the mean reported for the state of Minas Gerais in 2015, around 2060 $Kg.ha^{-1}$. Besides, nine of the thirteen lines showed grain yield above the national mean, around 5214 $Kg.ha^{-1}$ (CONAB, 2015). Therefore, all lines have potential to be selected in upland rice breeding programs to the state of Minas Gerais. However, careful should be taken in selecting lines considering only grain yield. Although highly productive, lines CMG1509 and CMG1896 had the worse performance for GD, what can be a limitation to its acceptance in the market. Whiteness is an important quality characteristic for rice consumers and grain discoloration drastically reduces the market value of rice.

Rice research institutions in Brazil have been dedicated to obtain lines that combine high grain yield with important agronomic qualitative traits, including tolerance to many important diseases that affect the plant performance in the field. Besides, there is a constant need to breed important crops due to the increasing world population combined with the changing habits and preferences of consumers. However, to release a new cultivar, it must present a better performance than the current cultivars found in market (Ramalho *et al*., 2012). Therefore, it is necessary to evaluate multiple genotypes for multiple traits to obtain superior cultivars and to supply market needs.

Conclusion

In this study, the lines with best performance for both grain yield and tolerance to the diseases considered were CMG1511, CMG2085, CMG2089, CMG1977, and CMG2170.

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