Performance of *B. rapa* varieties as turnip greens and turnip tops. Effect of environment and genotype

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Introduction

Brassica rapa is an important species of the genus *Brassica* widely cultivated in the world as a vegetable and for edible and industrial oil. In Galicia (Northwestern Spain) and in the coldest regions of Portugal *Brassica rapa* subsp. *rapa* L. includes three different crops: turnips, turnip greens and turnip tops. Turnips are the thickened roots, turnip greens are the young leaves harvested in the vegetative period, while turnip tops are the floral shoots and surrounding leaves. They have been under cultivation for a large period since they were among the first vegetables to be introduced into the Western Iberian Peninsula (Gómez-Campo, 1999).
A collection of *B. rapa* subsp. *rapa* from northwestern Spain is currently kept at 'Misión Biológica de Galicia' (CSIC, Spain). This collection was preliminary evaluated based on agronomical and morfological traits by Padilla et al. (2005). One hundred and twenty *B. rapa* varieties of this collection were evaluated finding that in many cases, the same landrace is sown for more than one purpose. However, the potential yield of these varieties and the stability of performance have yet not been explored. Based on this previous clasification twelve varieties were selected with the aim of determinining the most promising varieties for turnip greens and/or turnip tops fresh production to be included in future breeding programs.

Materials and Methods

Twelve local varieties of *B. rapa* were evaluated at three locations in Northwester Spain over two years. Varieties were transplanted in a randomized complete block design with three replications. Several agronomic and morphological data were recorded. The Sites Regression method (SREG) (Crossa and Cornelius, 1997) was used to study the fresh production of these varieties and the stability of the genotypes. Each environment was defined as the combination of a year and a location resulting in seven different environments under study. Since this method does not allow missing data, 11 varieties were evaluated for turnip greens assessment and seven varieties for turnip tops at five locations. For this method, principal components (PC) analysis was made on residuals of an additive model with locations as the only main effects. A two-dimensional biplot called GGE biplot (G plus GE interaction) of the two first PCs was plotted (Yan et al., 2000). Genotypes and locations were displayed in the same plot. These analyses were made by a SAS (SAS, 2007) program.

Results and Discussion

The analysis of variance for SREG showed that turnip greens fresh matter and turnip tops fresh production were significantly affected by E, which explained 44% and 40% of the total variation, respectively; while GGE accounted for 46% and 58% of total sum of squares. Genotype main effects (G) accounted for the 69% and 64% of the GGE variation of turnip greens fresh matter and turnip tops fresh production, respectively. Therefore, the variation due to G was larger than due to the GE interaction, but GE interaction was significant, meaning that differences among genotypes vary across environments.
The PC1 and PC2 together, which make up a GGE biplot, explained 89% and 90% of the total GGE variation of turnip greens and turnip tops fresh production, respectively. If the primary effects of sites from the SREG model are all of the same sign as it was in the present study, presents a noncrossover GE interaction (Fig. 1a and 1b) (Yan et al., 2000; Crossa et al., 2002). The two dimensional biplot for leaf fresh matter (Fig 1a) showed that MBG-BRS0550 and MBG-BRS0082 were the best genotypes in almost all studied environments, althought MBG-BRS0472 and MBG-BRS0184 also showed good performance at these environments. On the other hand, the varieties MBG-BRS0451 and MBG-BRS0163 had the highest fresh production at Oroso 2008. The low genotypic PC2 score found for MBG-BRS0472 represents proportionate response of the genotype across environments, which means a stable genotype. The two dimensional biplot for turnip tops fresh production (Fig. 1b) showed that MBG-BRS0472 and MBG-BRS0143 had the highest performance as turnip tops at all locations over years. The variety MBG-BRS0163 was the most stable genotype, but presented low values in all

environmments. The varieties MBG-BRS0173, MBG-BRS0197 and MBG-BRS0401 had bad performance as turnip greens and tops. Salcedo 2008 apeared as the most productive and stable environment for both crops.

Conclusion

Varieties evaluated in this work displayed enough variabiliy to differentiate among appropriate an stable varieties for turnip greens and/or turnip tops fresh production. The varieties MBG-BRS0550, MBG-BRS0082, MBG-BRS0184 and MBG-BRS0472 had good agronomical performance as turnip greens, besides this last variety was the most stable across locations and years. The suitable varieties for turnip tops production were MBG-BRS0472 and MBG-BRS0143. Salcedo was the most stable and productive location for both crops. For future crop breeding programs should be take GE interaction into consideration, which affect turnip greens and tops fresh production. Furthermore, the identification of the best variety at a specific growing environment would be useful to breeders and producers.

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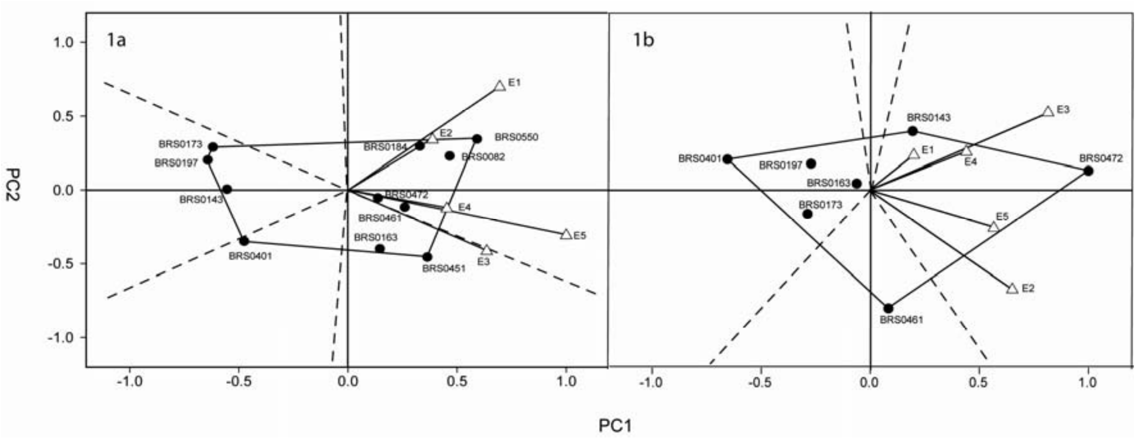

Figure 1. The G + GE interaction (GGE) biplot based on the fresh production of 11 *B. rapa* varieties for turnip greens (Fig. 1a) and five varieties for turnip tops (Fig. 1b) at five environments. Environments are E1 (Oroso 2007), E2 (Guitiriz 2007), E3 (Oroso 2008), E4 (Guitiriz 2008), E5 (Salcedo 2008). The polygon shown with tiny dots made with the genotypes which are on vertex. The intermediate sized dotted lines are the perpendicular lines to each side of the polygon; it shows which genotype(s) were grouped together as the most promising in a specific environment(s).