

Rank and related tests for grouping factor levels: An application to cocoa breeding experiments

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Talk Abstract

In the early 1930s, R. A. Fisher introduced an exact method for hypothesis testing by permuting data without changing its distribution under the null hypothesis. These permutations tests form the basis of classical nonparametric statistics, which itself is commonly associated with rank tests. Due their robustness against assumptions about the underlying data distribution, rank tests have gained popularity in many research fields, including agriculture and finance, to name just a few. In 2023, Opoku-Ameyaw et al. proposed a nonparametric test for grouping levels of a factor. This test was applied to a cocoa breeding experiment in Ghana, to evaluate the performance of adaptability of twelve varieties of cocoa on four types of acidic soils. There were three groups of varieties, two of which were of a common ascendant, and the homogeneity of these two groups was tested. The results revealed that the grouping is significant for the most acidic soil. The present study proposes a randomization procedure inspired by Fisher's randomization method, which aims to derive the exact distribution of the test statistic considered in Opoku-Ameyaw et al. (2023), focusing on both univariate and multivariate cases. The obtained results corroborate the findings of the previous work, providing further evidence of the applicability and relevance of the proposed approach.

Keywords: Nonparametric test, Fisher's randomization method, univariate test, multivariate test, cocoa breeding experiment.

Acknowledgements

This work was partially supported by national funds of FCT-Foundation for Science and Technology under UIDB/00212/2020 and UIDB/00297/2020.

References

- [1] Ahenkorah, Y., Appiah, M.R., Modal characteristics of soils within the COCOBOD plantations of Ghana, *Proceedings from Ghana Soil Science Association*, 11, 1992, pp. 13–16.
- [2] Boos, D.D. and Stefanski, L.A., *Essential Statistical Inference: Theory and Methods*. Springer Texts in Statistics. Springer New York Heidelberg Dordrecht London, 2013.
- [3] Conover, W.J. *Practical Nonparametric Statistics*, 3rd Edition, Wiley Series in Probability and Statistics, John Wiley & Sons, 1999.
- [4] Dogbatse, J.A., Arthur, A., Padi, F.K., Konlan, S., Quaye, A.K., Owusu-Ansah, F. and Awudzi, G.K., Influence of Acidic Soils on Growth and Nutrient Uptake of Cocoa (*Theobroma Cacao* L.) Varieties, *Communications in Soil Science and Plant Analysis*, 51(17), 2020, pp. 2280–2296.
- [5] Fisher, R.A., *The Design of Experiments*, Oliver and Boyd, 1935.
- [6] Opoku-Ameyaw, K., Nunes, C., Esquivel, M. L. and Mexia, J.T., CMMSE: a nonparametric test for grouping factor levels: an application to cocoa breeding experiments in acidic soils, *Journal of Mathematical Chemistry*, 61(3), 2023, pp. 652–672.
- [7] Scheffé, H., *The analysis of variance*, Wiley series in Probability and statistics, John Wiley & Sons, New York, 1959.