The aim of subset selection methods is to select a non-empty subset including the best populations with some desired probability, based on some chosen parameter. However, it is well known that the method can become too conservative when the parameter configuration is not least favourable. This will lead to a large subset including many non-best populations, making the result less informative. To solve this issue, we propose several approaches based on the Schweder-Spjøtvol estimator that better adapts to the underlying parameters, and give less conservative results through the reduction in multiple testing corrections. Further, we also present adaptive methods that are still applicable when the sample sizes and/or variances are unequal between populations. We show that both the theoretical and simulated results give desirable performances. We also apply our methods to two real datasets, one with the aim to find a subset of the most productive wheat, and the other to find a subset that includes the true selective target in evolve and resequence experiments. Our results suggest that our adaptive approach reduces conservativeness significantly in both scenarios.