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Enhancement of yield by increasing ovule initiation in *Arabidopsis thaliana*

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Abstract

Food security is a growing risk with the exponentially increasing population. Current methods of increasing crop output are causing serious damage to valuable habitats. One potential solution to this problem is to increase the yield of crops. *Arabidopsis thaliana*, the model organism for plants, is a member of the Brassicaceae family of plants; this is an economically important group of plants as it contains many crop plants, such as the cabbage. Using a molecular biology approach, I investigated the potential of using a genetic mutant resistant to a plant growth factor (BZR1-1D) as an alternative to the wildtype (Col-0), the type which appears most commonly in nature, of *A. thaliana* to produce more seeds as a way of increasing yield. This has been done by growing wildtype and BZR1-1D mutant lines and harvesting the siliques (fruiting bodies which contain the seeds). I measured the length of the silique and counted the number of seeds in each and found that the mutant (BZR1) has a higher average ratio of silique length to total seed number but the same average number of seeds. This finding can potentially be used to inform further studies into increasing yield of crop plants such as Oil Seed Rape which is a member of the same family.

Introduction

Hypothesis: increasing ovule number is an effective way of increasing seed yield.

One of the significant problems at the moment is how to feed the world's growing population. Between 1950 and 2011, the global grain harvest tripled (Cassman *et al.*, 2003). In recent years the increase in crop yield has plateaued. The most common way to increase crop production is to increase the area of land the crop is grown on, however this is destroying valuable ecosystems. This is unsustainable because there will come a point when no more arable land can be created. Another method used to increase yield is irrigation, however irrigation can have lasting impacts on soil quality. In dry areas water availability is a limiting factor. Often salination occurs; when excess water is used to irrigate crops the excess evaporates off the surface leaving behind salt deposits. Over several years the concentration of salt in the soil increases and reaches levels that most crop plants find intolerable. This means that even more arable land must be created and the cycle continues causing even more destruction of valuable habitats. Before this point is reached it is integral that we create a solution to increase output without using up any more land.

In situations where seeds are the most important part of the crop, e.g. oil-seed rape, wheat, maize, and rice, the best way to increase yield is to produce plants that have a higher number of seeds with no concomitant decrease in their size or quality. One way to do this is to increase the number of ovules that a plant produces. Several lines of evidence now suggest that this is possible.

Papers have reported on *Arabidopsis* lines with increased ovule numbers (Bartrina *et al.*, 2011; Bencivenga *et al.*, 2012; Huang *et al.*, 2013). Whether increased ovule initiation results in yield increases was not explicitly commented upon in these papers although there is some evidence that seed number was increased. Yield is, of course, related to seed number but no study has examined seed size and oil quantity in the scenario of increased ovule production.

A Silique of *Arabidopsis thaliana*

Method

The seeds of both the mutant (BZR1) and the wildtype (Col-0) were planted in the greenhouse and allowed to grow until they had produced flowering stems with fully developed siliques present. The siliques were harvested and taken to the laboratory for analysis. In order to preserve the siliques for analysis at a later date they were fixed using a solution of 50% methanol, 10% acetic acid and 40% water.

The siliques were measured in millimetres before being placed on a microscope slide for the number of ovules to be counted. This was done by placing a coverslip over the silique and gently pressed down. Once the measurements had been recorded the siliques were discarded. This was performed for approximately 150 siliques of each genotype.

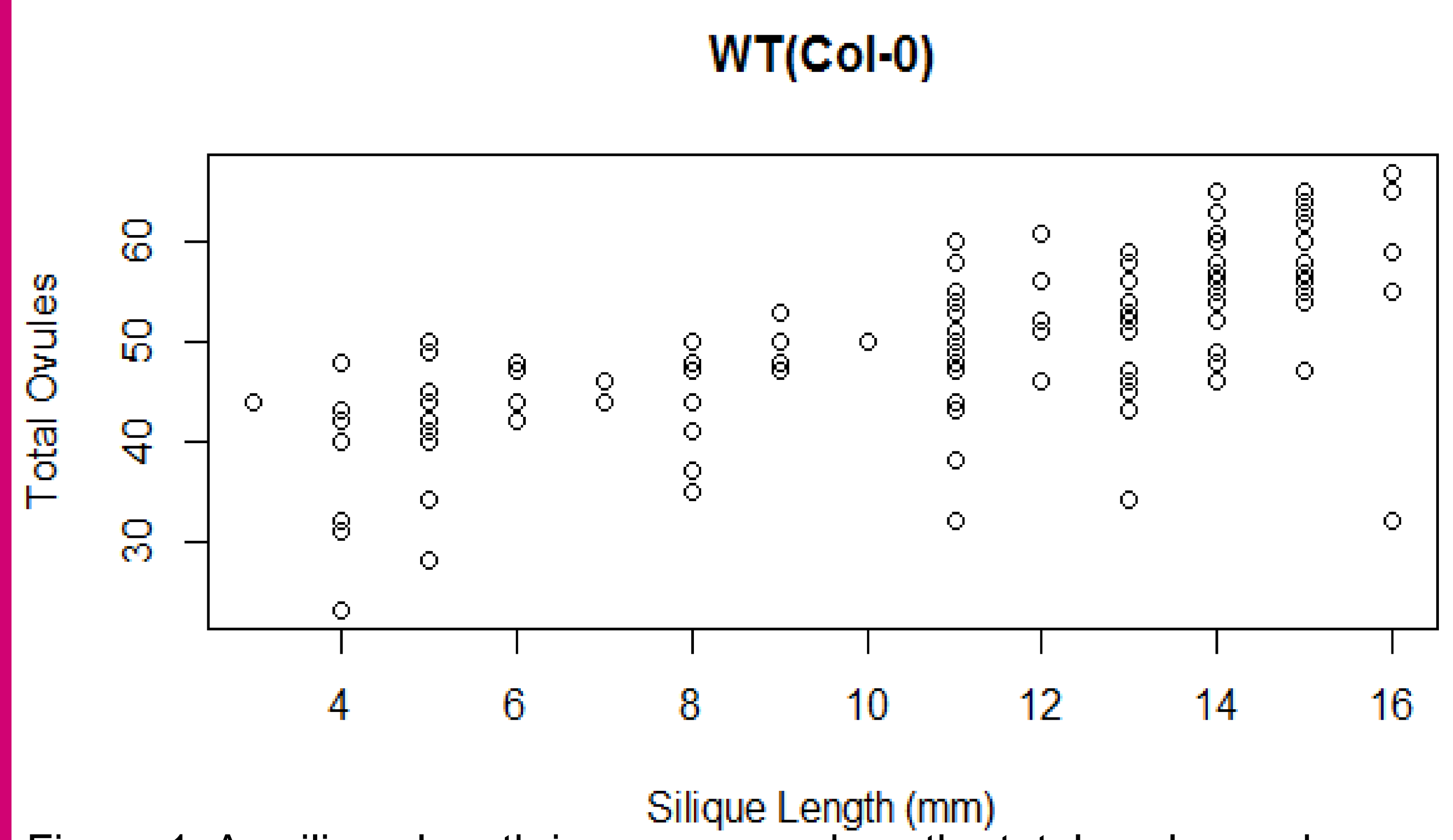

Figure 1: As silique length increases so does the total ovule number.

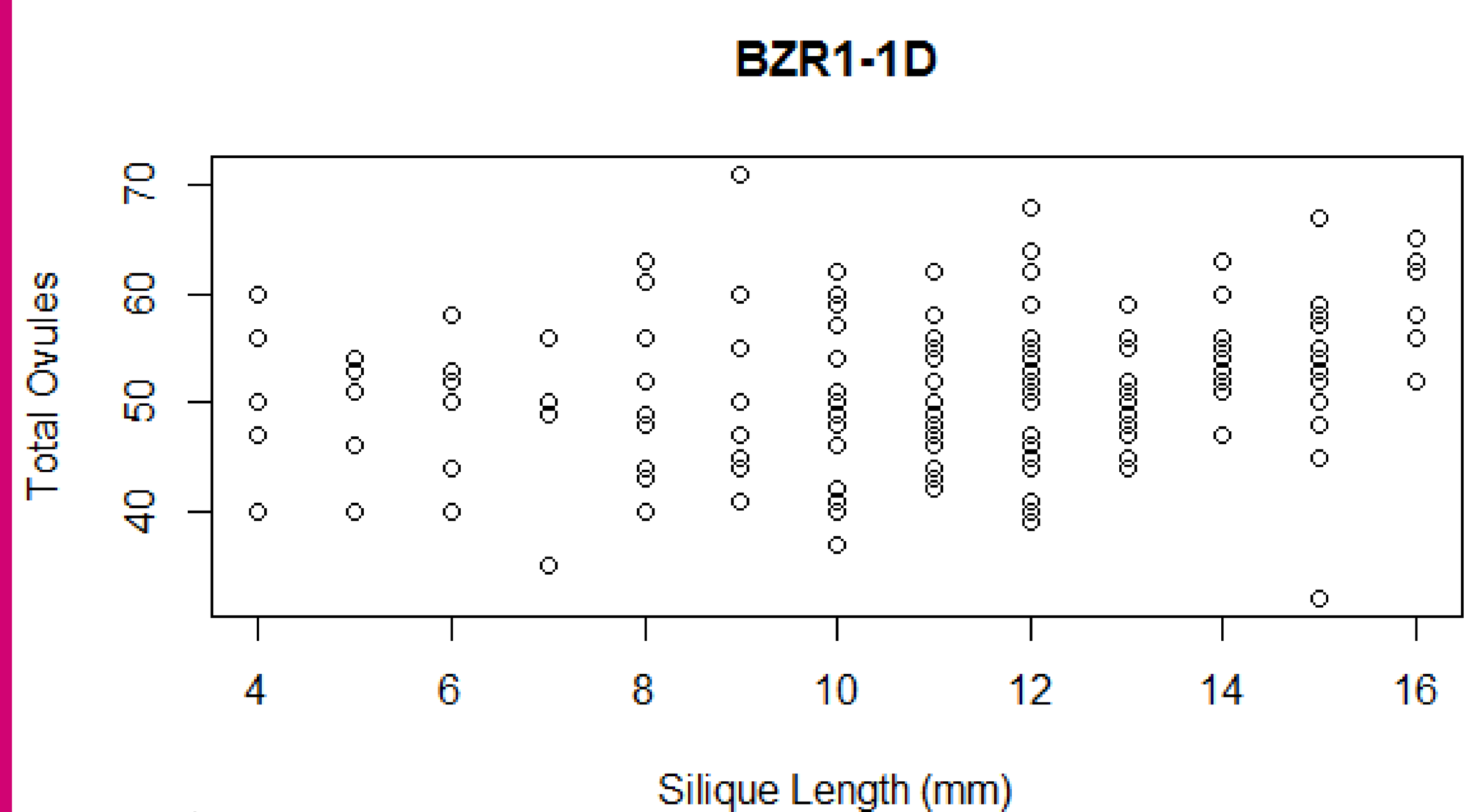

Figure 2: The relationship between the two variables is less obvious.

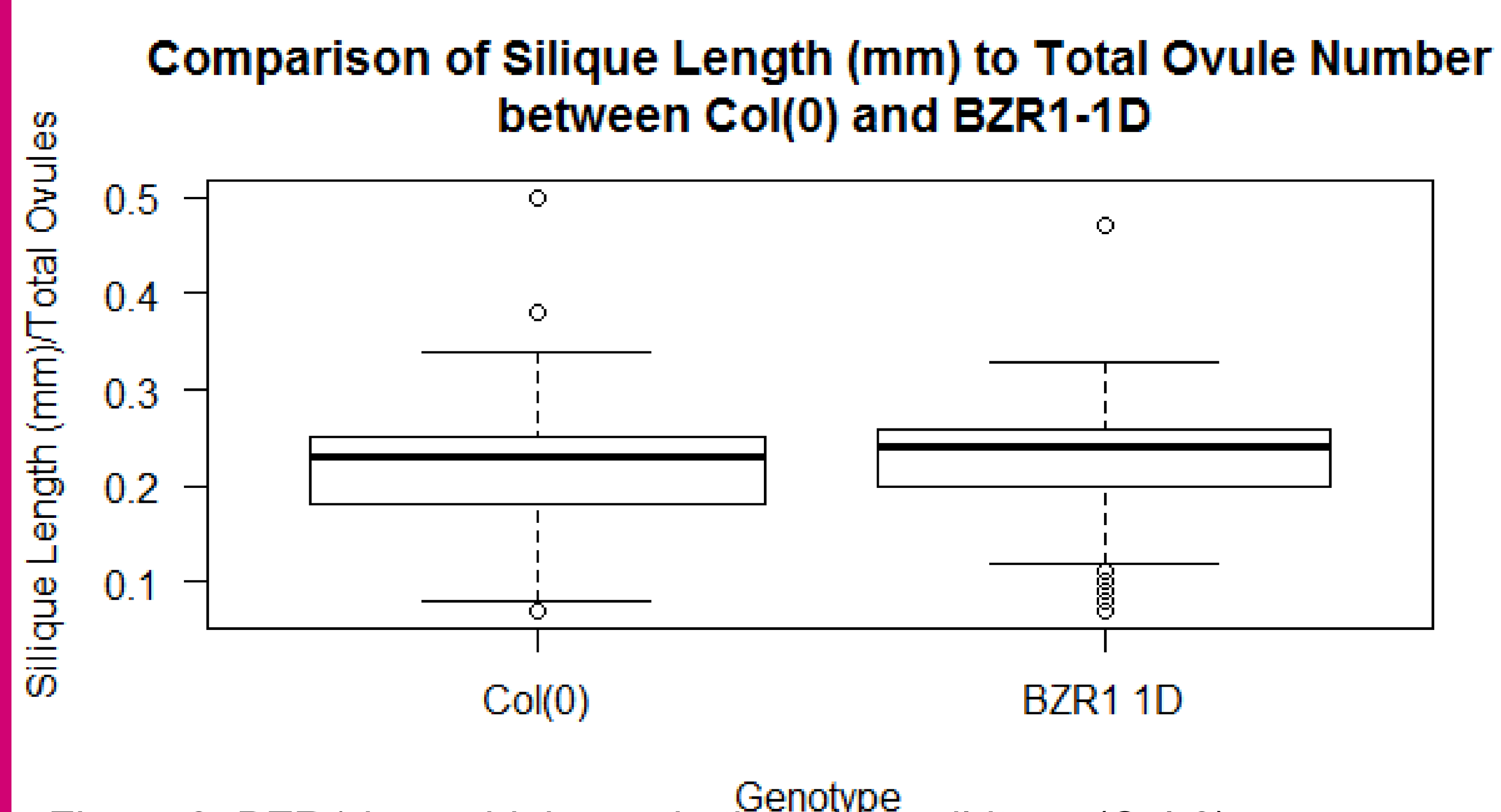

Figure 3: BZR1 has a higher ratio than then wildtype (Col-0)

Conclusion

It was found that the mutant and the wildtype have the same average number of ovules (50) but the mutant (BZR1-1D) had the highest total ovule number. However, in the wildtype (Col-0) plants there is a positive relationship between the length of the silique and the total number of ovules (Fig 1). This relationship is reduced in the mutant (BZR1)(Fig 2). This suggests that small siliques of BZR1-1D can produce the same number of ovules as the Col-0 plants and thus the energy input needed would be decreased. By using the mutant genotype the number of resources to obtain the same number of siliques would be decreased which is a positive for the environment. This is supported by the higher ratio in BZR1-1D of silique length to total ovule number (Fig 3). The next step in this field of research is a further study into whether or not yield is increased by increasing ovule number.

References

Cassman, *et al.*, 2003, *Annu. Rev. Environ. Resour.* 28, 315-358; Bencivenga *et al.*, 2012, *Plant Cell* 24, 2886-2897; Bartrina *et al.*, 2011, *Plant Cell* 23, 69-80; Huang *et al.*, 2013, *Mol. Plant* 6, 456-469. Image and figures are author owned.