LINDENWOOD
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The Effect of Gibberellic acid Treatment on the Growth of Dwarf Millet Mutants

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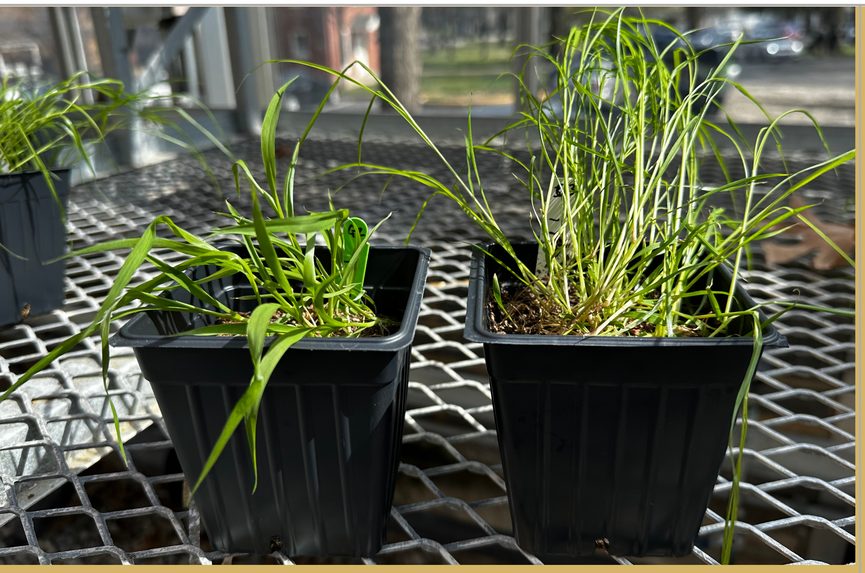


01. Abstract

Dwarfism is a common mutation found in many organisms and Setaria (millets) is no different. In millets and other plants, a reduction or complete lack of production of necessary hormones such as Gibberellic acid (GA), auxin, or Brassinosteroid can cause a mutant's vertical and sometimes outward growth to be significantly reduced when compared to a wild type of the same variety. A typical solution to this mutation is the application of a hormone solution to allow the plant's cells and organs to have access to the hormones needed to continue growing at an average rate. We decided to test an application method by applying a solution of 15 ppm of GA in 1L of water, at three different rates to four different varieties of millet including one wild type and three different mutant types. Our experimental results come from measuring the plant's growth (using centimeters) three times a week and recording that data to find the average growth of each group. We have been testing this experiment over the course of three weeks and will be presenting evidence to show that the application of Gibberellic acid solution improves the growth of all millets including Dwarf mutants.

02. Objective

To find the effect of a GA solution on millets with dwarfism mutations
To understand how GA will affect phenotype and override parts of the genotype.

Background Sources

Achard, P., Gong, F., Cheminant, S., Alioua, M., Hedden, P., & Genschik, P. (2006). The cold-inducible CBF1 factor–dependent signaling pathway modulates the accumulation of the growth-repressing DELLA proteins via its effect on gibberellin metabolism. Plant cell, 18(11), 2692-2705.

Hedden P. The Current Status of Research on Gibberellin Biosynthesis. Plant Cell Physiol. 2020 Dec 23;61(11):1832-1849. doi: 10.1093/pcp/pcaa092. PMID: 32652020; PMCID: PMC7758035.

Kumar, S., Datta, K.S. & Nanda, K.K. Gibberellic-acid causes flowering in the short-day plants Panicum miliaceum L., P. miliare lamk., and Setaria italica (L.) P. Beauv.. Planta 134, 95–96 (1977). https://doi.org/10.1007/BF00390101

Kumawat, S., Sharma, V., & Sharma, R. (2016). Effect of gibberellic acid (GA3) on yield attributes, yield and economics of wheat. Indian Journal of Agricultural Research, 50(2), 169-172.

Ma Y., Xue H., Zhang L., Zhang F., Ou C., Wang F, Zhang Z. Involvement of Auxin and Brassinosteroid in Dwarfism of Autotetraploid Apple (Malus × domestica). Sci Rep. 2016 May 24;6:26719. doi: 10.1038/srep26719. PMID: 27216878; PMCID: PMC4877651.

Mahajan, P., Kumar, V., & Sharma, A. (2020). Gibberellic acid (GA3) induced changes in morpho-physiological traits and yield of pearl millet (Pennisetum glaucum L.) under drought stress. Research on Crops, 21(3), 398-404.

Muangprom A, Thomas SG, Sun TP, Osborn TC. A novel dwarfing mutation in a green revolution gene from Brassica rapa. Plant Physiol. 2005 Mar;137(3):931-8. doi: 10.1104/pp.104.057646. Epub 2005 Feb 25. PMID: 15734906; PMCID: PMC1065394.

Singh, V., Chaudhary, D. P., Singh, A. K., Kumar, A., & Kumar, S. (2019). Effect of foliar application of gibberellic acid on growth and yield of dwarf pearl millet. Environment and Ecology, 37(4C), 2302-2305.

Sudhakar, C., Lakshmi, A. Y., Giridhar, P., & Parvathi, M. S. (2016). Biochemical characterization of finger millet (Eleusine coracana) genotypes for nutritive components. Journal of Food Science and Technology, 53(2), 1192-1198.

Wang, X., Wang, L., Liu, X., Li, C., & Liu, X. (2021). Exogenous gibberellin acid affects the growth and quality of wheat seedlings under low light intensity. PLoS ONE, 16(2), e0246684.

03. Methodology

We created a GA solution with 15ppm of GA power in water. Planted one pot for each of the four types of seed per the 3 levels including a control set for a total of 16 pots. Each treatment level had a different number of GA solution applications:

- **Treatment level 1:** application four times a week (M,T,W,F)
- **Treatment level 2:** application two times a week (M,Th)
- **Treatment level 3:** application once a week (W)
- **Control group:** Had no application of a GA solution and only received water.

Once all pots had at least one successful growth, we started the application of the GA solution. We began measuring twice a week to collect data on the differences in growth.

04. Results/Discussion

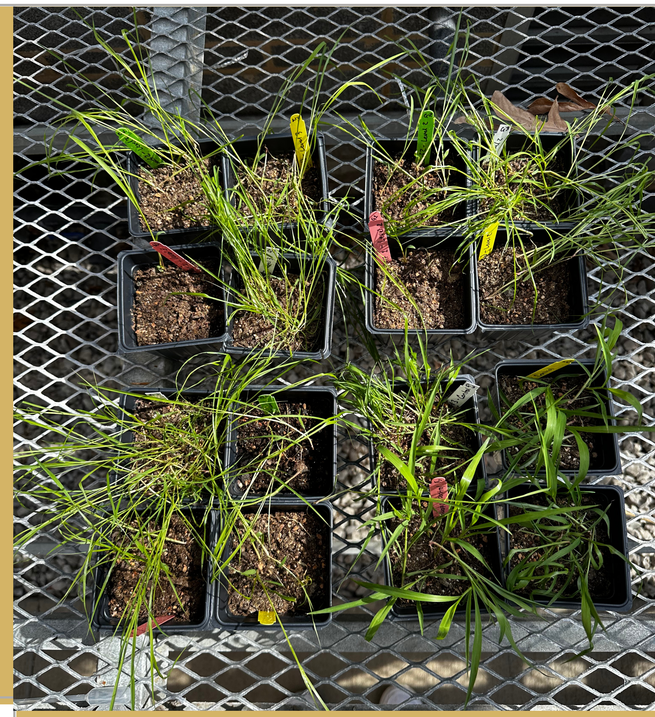
For ease of recording data, each millet type was labeled with a colored marker as follows:

- Control Wildtype - Yellow (Fig. 4)
- Mutant 1: 00256 M3 - Pink (Fig. 2)
- Mutant 2: 22970 M3 - Green (Fig. 1)
- Mutant 3: 11842 M4 - White (Fig. 3)

Average growth across treatment levels: Level 1 had an average increase of 3.969 cm across all four types of millet which was the largest across all three treatment levels, Level 2 had an average of 1.781 cm across all four types, and Level 3 had an average of 2.75 cm across all four types.

Average growth across millet type: The control wildtype had the largest difference in average growth across all three treatments with a growth difference of 3.841 cm. Out of the three mutant types, Mutant 3: 11842 M4 had the largest growth difference average when compared to the control pot with an average growth distance of 3.8 cm. Mutant 2: 22970 M3 had an average of 3.567 cm average growth difference. Mutation 1: 00256 M3 had the smallest difference in average growth when compared to the control pot with only 0.125 cm.

One thing we noticed was that the control group had wider leaves which could be contributed to how energy was spent during growth, with the test groups being forced to grow vertically while the control could spend energy to grow wider leaves. Additionally, despite having the same number of seeds per pot (20), the Mutant 3: 11842 M4 pots had the densest growth while the Mutant 1: 00256 M3 pots had an average of less than 5 shoots total in the pot.



05. Data Results

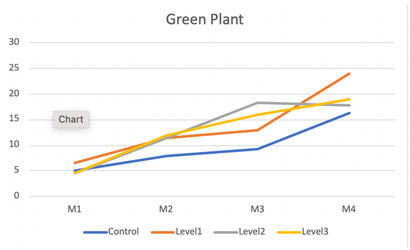


Figure 1-Mutant 2: 22970 M3 - Green

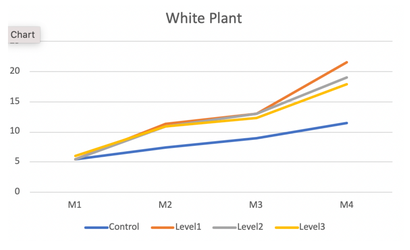


Figure 3- Mutant 3: 11842 M4 - White

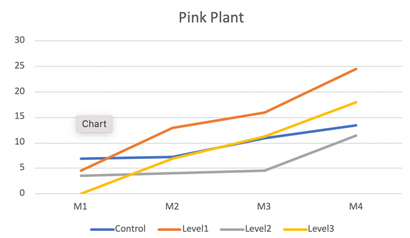


Figure 2- Mutant 1: 00256 M3 -Pink

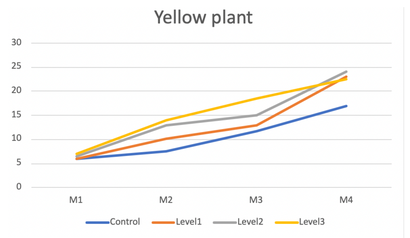


Figure 4- **Control Wildtype - Yellow**

06. Conclusion

Our experimental results show that *the application of a GA solution has an impact on the phenotype of millets even when the genotype codes for dwarfism mutations*. We found that treatment level 1 had the largest difference in growth when compared to the control. Mutation 1: 00256 M3 in treatment levels 2 and 3 grew smaller than the control causing the average growth difference to be much smaller than the other millet types. The application and treatment of this acid not only contribute to plant growth but also impact the plant's leaf structure. All of the control groups developed the same type of leaves (thicker and shorter) compared to the other 3 treatment levels, which grew leaves that were thinner but taller.

We believe this experiment is important due to how common dwarf mutations can be in plants, especially crops, and by understanding how to use gibberellic acid to influence their growth, scientists can work towards larger crop yields and healthier plants.