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Editorial

Can We Create a New Green Revolution to Avert the Coming Global Food Crisis?

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Editorial

Probably one of the most important examples of how plant and crop science research has impacted world food security is the green revolution. The green revolution of the 1930's – 1960's dramatically increased food production in the world. The great driving force behind the green revolution was Norman Borlaug. He led a global initiative to introduce wheat and rice cultivars with shorter stems, which gave a higher yield, and advocated the use of fertilizers, pesticides and herbicides. These improved agricultural practises dramatically increased food production around the world. The cultivars with shorter stems were less susceptible to logging, could handle larger amounts of nitrogen fertilizer and had higher grain yields. Norman Borlaug was awarded the Nobel Peace Prize in 1970 and is credited with saving a billion people from starvation. Subsequent research discovered that the genes responsible for the short stem phenotype were involved in the gibberellin signalling pathway [1]. Peng et al. 1999 showed that the mutant alleles in the cultivars with the dwarfing phenotype were orthologues of the Arabidopsis *Gibberellin Insensitive (GAI)* gene. Currently humanity is facing a similar crisis in food security. In the coming thirty years, the world population is predicted to increase from the current 7 billion to about 10 billion people by 2050 [2]. This will put a severe strain on our ability to produce enough food, while preserving the world's ecosystems. Besides that, there is also a growing demand for renewable energy and industrial chemicals from agricultural products. In order to meet these challenges, agricultural productivity will have to increase significantly [3].

There are a few options to address this problem, one of which is to create crops that produce more per acre with fewer inputs. However, this cannot be achieved by only using conventional plant breeding practices. We will need to use modern genome engineering technologies to reach the required increases in crop productivity. There are many success stories, which show that Genetic Modification (GM) technologies can be used to significantly increase agricultural productivity and simultaneously reduce the impact on the environment by for instance reduced pesticide use, especially in developing countries. The success of GM crops is shown by the rapid adoption of this technology by farmers. In the 16 years since the introduction of the first GM crops in 1996, the area of GM crops grown by farmers has increased to 160 million hectares [4].

One example of a success story is the use of the *Bacillus thuringiensis* (Bt) gene that confers resistance to insect pests when expressed in crop plants. For instance, in India the use of the Bt gene in cotton in order to make it resistant to bollworms has been very successful. In trials conducted there in early 2000's it was shown that pesticide use was reduced significantly and yields were up by 80-90% in Bt Cotton in comparison to conventional varieties [5]. As a result of the success of these trials, 10.6 million acres of Bt cotton were grown in India in 2011 [4]. However, the full potential of GM technologies for creating the next green revolution has not been reached yet. In order to make use of the full potential of these technologies, public acceptance of GM crops and funding for plant and crop science research will have to be increased. The negative attitude of the public and national governments towards these technologies in many countries is still hampering the development and commercialisation of disease resistant high yielding GM crop varieties. For instance, in the European Union obtaining funding for research involving transgenic crop plants is nearly impossible and companies are in general not allowed to grow their GM crop plants or import food products produced with GM technology.

Besides these applied aspects of plant and crop science, basic plant science has greatly contributed to our understanding of fundamental processes in living organisms, such as heredity and gene regulation [6,7], hormone signalling [8] and Ribonucleic Acid (RNA) interference [9]. For instance, the rules for inheritance of genetic traits were discovered by Gregor Mendel using peas between 1856 and 1863 [6]. Barbora McClintock discovered transposable elements, for which she was awarded the Nobel Prize in Physiology or medicine in 1983 [7]. The first gaseous signalling molecule identified in living organisms, ethylene, was identified in plants in the early 1900's. In 1934, it was discovered that plants produce ethylene and that it's responsible for fruit ripening [8]. RNA interference was first discovered in plants. In the 1990's it was observed that over expression of genes in plants can silence the endogenous homologous genes by reducing their expression level [9]. Soon it was observed that similar mechanisms existed in other organisms. In 2006 the Nobel Prize in Physiology or Medicine was awarded for elucidating the molecular mechanism behind RNA interference in *C. elegans*.

These examples show that plant science has contributed greatly to our understanding of biological systems, although it has not received the deserved recognition for this, as shown by the fact that the discovery of the first gaseous signalling molecule in living organisms, ethylene, was overlooked by the Nobel Prize committee. In 1998 Robert F. Furchgott, Louis J. Ignarro and Ferid Murad were awarded the Nobel Prize in Physiology or medicine for discovering that nitric oxide is a signalling molecule in humans. The Nobel Prize committee claimed that this was the first time that a gas was shown to be a signalling molecule in biological systems [10] "Signal transmission by a gas that is produced by one cell, penetrates through

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membranes and regulates the function of another cell represents an entirely new principle for signalling in biological systems". This lack of recognition for plant science is also reflected in the division of science funding in for instance in the United States. The budget for the National Institutes of Health is about 30 billion dollars a year, while 1 billion is allocated to basic research in the area of evolution, ecology, microbiology and plant biology [11]. The result of this lack of funding and recognition for the value of plant and crop science research is that many of the best and brightest minds in life science opt out of a career in plant and crop science research. This is another important factor that is seriously hampering our efforts to solve the food security issues we are currently facing. The accomplishments of Norman Borlaug show the importance of recruiting and retaining top scientist in the field of plant and crop sciences in order to solve the current food security issues.

I am fully convinced that we can solve our problems with food security and create a new green revolution, which will allow us to feed 10 billion people in 2050. For this to be achieved, it's essential that public acceptance of GM crop technology will be increased. A lot of the opposition to GM technologies stems from irrational fears, driven by a poor understanding of this subject. These fears can be overcome by improved education and designing more rational government policies related to this issue. Government policies related to the approval of GM crops are unnecessarily strict and costly at the moment and streamlining the process of approval would speed up their commercialisation. In addition to this, funding for plant and crop sciences needs to be increased significantly. For this it's necessary to convince the public and governments about the seriousness of the food security issues we are facing worldwide. With increased funding and recognition for plant and crop sciences, we will be able to attract and retain the brightest scientist in our community and tackle the big problems we are facing.

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