Crop wild relatives
A valuable resource for crop development
Overview

With the global population set to reach approx. 9.6 billion by 2050\(^1\), it is reported that agricultural production will need to increase by 70%\(^2\). In order to satisfy this demand, production will need to continue to grow at similar rates to that achieved in the past which includes the dramatic impact of the Green Revolution\(^3\). Furthermore, due to the expected downward pressure on productivity from a variety of factors, including climate change and land use development, a significant shortfall in agricultural production is predicted.

CWRs are an important source of genetic biodiversity which can be utilised in the breeding of improved crop varieties. CWRs hold the potential to increase agricultural production, making them a valuable resource to the agricultural system\(^4\).

We estimate the potential value of CWRs to the future production of the MSB’s 29 priority crops to be $120bn. This compares to an annual gross production value (‘GPV’) of these crops of $581bn in 2010. This highlights the importance of CWRs to the future of agricultural production. It is therefore viewed that their loss would have a significant impact on our ability to meet the demands of the future global population.

### What are CWRs?

CWRs are the wild species closely related to crops and they have the potential to contribute beneficial traits for crop improvement\(^5\), such as disease resistance or tolerance to drought. They are viewed as a significant source of biodiversity for crop production and their use in the breeding of new crop varieties is likely to prove important.

### How could we benefit from CWRs?

CWRs can provide diverse genetic material for crop breeding which may lead to the development of improved, higher yielding crop varieties, with beneficial traits such as increased overall productivity and improved tolerance to biotic and abiotic stresses.

#### Examples of abiotic and biotic stresses:

**Abiotic**
- Extreme temperatures
- Drought
- High winds
- Soil quality (including salinity, pH, etc)

**Biotic**
- Bacteria
- Viruses
- Fungi
- Insects
- Other plants

Over the past several decades, case studies have demonstrated the benefits of using CWRs in the development of improved crop varieties. Ongoing research suggests that CWRs are likely to provide significant benefits to increasing agricultural production in the future\(^6\).

Our research highlighted a number of case studies of the benefits derived from CWRs through improvement of crop varieties.

#### i) Resistance to potato late blight

Potato late blight is one of the most damaging diseases for potato, and its negative economic impact is thought to be $3.5bn per year in developed countries alone\(^7\).

Resistance to late blight in the current European potato varieties has been exclusively derived from CWRs. Varieties of potato with CWR-derived late blight resistance such as the C-88 potato are also being introduced into China.

In one of the case studies, it was estimated that CWR derived resistance was responsible for preventing the loss of approximately 30% of the annual yield, where conditions for blight were prevalent.

#### ii) Improved abiotic tolerance of wheat

Wheat varieties such as ‘Veery’ have benefitted from the introduction of genes from rye, a relative of wheat. The beneficial traits inherited include tolerance to extremes of temperature and drought conditions, as well as resistance to a variety of wheat diseases such as wheat rust\(^8\).

These wheat varieties have had a significant impact in the developing world, as well as developed world markets such as the US.

### Many CWRs face risk of extinction

There is a considerable risk that many of CWRs are lost through changes and damage to their habitats driven by climate change and continued land use development, which could lead to their extinction in severe cases\(^9\).

This could lead to genes with specific beneficial traits being lost from the gene pool, leaving less genetic resources and potential solutions with which to meet the demand for increased agricultural production.

### Why was this study commissioned?

The MSB sought to understand the current and potential value of CWRs in order to support their business case for increased investment for the collection and research of CWR material.

This study also allows the MSB and other stakeholders in the value chain to better understand the value of the wider benefit of their collection and research activities.

### Contributors to our research

We interviewed 38 different industry experts, all key stakeholders in the value chain, as illustrated below.

*Academic and research groups*
- Key institutions focused on CWR research
- Key pre-breeding research institutions

*Commerical contacts*
- e.g. Seed breeders, seed merchants and crop growers

*Industry specialist groups*
- e.g. Trade associations, government bodies and industry consultants

The interviewees have provided us with current and historical case studies of CWR use in crop development, as well as guidance on key assumptions underlying our analysis.
Key assumptions underpinning our valuation

Our analysis has been based on a number of key assumptions. The most influential assumptions are summarised below.

Basis of value: We have estimated the incremental economic benefit from use of CWR material in breeding programs based on gross production value. This is the value received by farms from the sale of agricultural produce at the farm gate. We selected this basis so that our valuation analysis covers the full value chain up to farm gate sales, and allows us to analyse the value accruing to many stakeholders.

Projections: We have used publically available forecasts of gross production values for our crops until 2021, sourced from the Food and Agricultural Organization of the United Nations (‘FAO’) in collaboration with the Organisation for Economic Co-operation and Development (‘OECD’).

Extrapolation: Our analysis was performed on 4 sample crops of potato, rice, wheat and cassava. We took the average value uplift in these crops from CWR benefits, and applied a simple extrapolation method to estimate the current and potential value for the MSB’s 29 current priority crops, using a pro-rata uplift based on relative 2010 gross production values.

Valuation methodology

We have performed our valuation exercise on four sample crops of wheat, rice, potato and cassava, and have extrapolated our findings across MSB’s 29 priority crops.

For each of our sample crops, we have analysed the current and potential value of CWR traits using inputs derived from existing case studies which show examples of traits conferring:

- **Yield improvement** – CWR genes can result in an uplift to the total production of a crop variety through yield improvements;
- **Disease resistance** – the yield loss saved due to resistance against a disease (e.g. fungal or bacterial) that is conferred by the transfer of resistance genes from CWRs; and
- **Abiotic stress tolerance** (e.g. drought, heat) – abiotic stresses cause losses to the crop yield as they impact upon the growth ability of the plants. CWRs can help to reduce this loss through improving the tolerance of commercial varieties. It is this yield loss saving that we assume and value as the benefit.

We have used the findings from these case studies to analyse the current value and also to inform our assumptions for potential value of CWR traits in future crops.

Current value is derived from the economic benefit over the useful economic life of traits in current crops. Potential value is derived from economic benefits from future improved crops into perpetuity given that the CWR collection will be preserved for hundreds of years.

Value is attributed to the ‘system’ producing these crops and we have not sought to allocate our assessment of value to any particular stakeholder within the value chain. In addition, we have not considered the value downstream, i.e. post farm gate.

Important assumptions we have adopted are outlined in the ‘Key assumptions underpinning our valuation’ section opposite.
Our valuation of CWRs

The current and potential values of CWR benefits attributable to the whole of the crop production value chain, such as pre-breeding, breeding, and farming activities in commercial cultivars, are of significant magnitude, being $25bn and $73bn respectively for our sample crops.

Using a simple extrapolation method based on pro-rata 2010 gross production value figures for crops, the current and potential value of benefits from CWR traits for the MSB’s 29 current priority crops are $42bn and $120bn respectively.

If we include the extrapolation of maize, soya bean and sugarcane, which are not yet part of the current priority crops for the MSB, the current and potential values increase to $68bn and $196bn respectively.

To put our valuation into context, the annual global gross production value of the MSB’s 29 current priority crops was $581bn in 2010, with the gross production value rising to $950bn if maize, soya bean and sugarcane are included in addition to the 29 priority crops.

Key matters arising from our study

Based on our assessment of the potential value of MSB’s contribution to crops developed to withstand biotic and abiotic factors, it is clear that there is a substantial value in the use of CWRs for future crop development.

Our value accrues to stakeholders in the crop value chain which includes academics, pre-breeders, commercial breeders and farming stakeholders; as well as society in general through increased agricultural productivity both in the UK and abroad.

A large proportion of the benefit is therefore not for the private sector, but more for society and the public good.

Without adequate funding for CWR collection, there is a risk that many of the in situ wild relatives will suffer from a loss of genetic diversity, or in severe cases become extinct. This could lead to the loss of genes with specific traits of potential value.

Investment is also necessary in the research of CWR traits feeding into crop development, as without this the potential value of the CWR collections may remain locked away without realising their potential.

Concluding remarks

From our work, we note that many stakeholders, both public and private, and not least society in general stand to benefit significantly from the use of CWRs in crop development.

It was a consistent view from many stakeholders that there is a need for a greater level of funding in both the collection and research of CWRs and their traits.

Greater collaboration is also required across all stakeholders in the value chain to ensure CWR benefits are maximised and both public and private sectors stand to benefit.

As the global environment changes, many academics identify the risk of a significant shortfall in crop production to meet the needs of the growing global population. In order to bridge this gap, new crop varieties will be needed to improve production. The expectation is that CWR genetic material will play an important role in the development of these new varieties.

Given the threat to in situ CWRs in their natural habitats, a key imperative is for CWRs to be collected and preserved so that all stakeholders and the wider society can benefit from the genetic diversity they offer.

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References

1. World Population Prospect: The 2012 Revision; United Nations, Department of Economic and Social Affairs, Population Division; June 2013

2. How to feed the world 2050, High-level expert forum, Global agriculture towards 2050, FAO (2009)

3. The ‘Green Revolution’ refers to the period, often referred to as the 1960s to 1980s, which saw the global spread of high yielding modern varieties of crops combined with associated improvements in farming practices and technologies. This resulted in worldwide increases in agricultural production. For more information, please refer to: http://www.fao.org/docrep/003/w2612e/w2612e06a.htm

4. Interviews conducted with various industry experts


6. Alien introgressions as a rich source of resistance genes; Gill, B.S., Friebe, B.R., and White, F.W.; PNAS (2011)


8. Establishment of a global network for the in situ conservation of crop wild relatives: status and needs; Maxted, N and Kell, S.P.; FAO Commission on Genetic Resources for Food and Agriculture (2009); p3