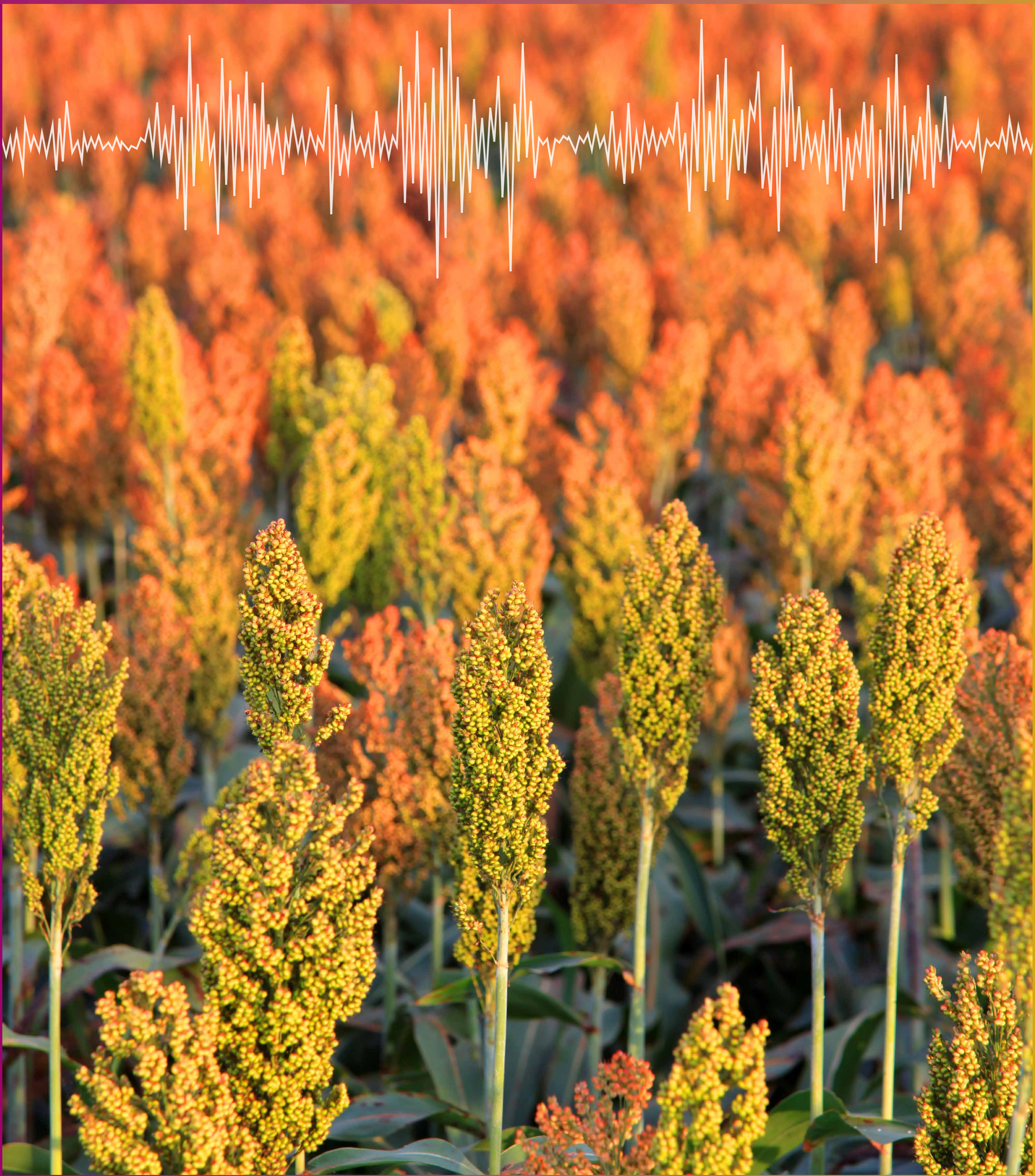
SCIPOD

DEVELOPING DROUGHT AND WEED RESISTANT SUPER-SORGHUM

Dr Kahiu Ngugi



Developing Drought and Weed Resistant Super-Sorghum

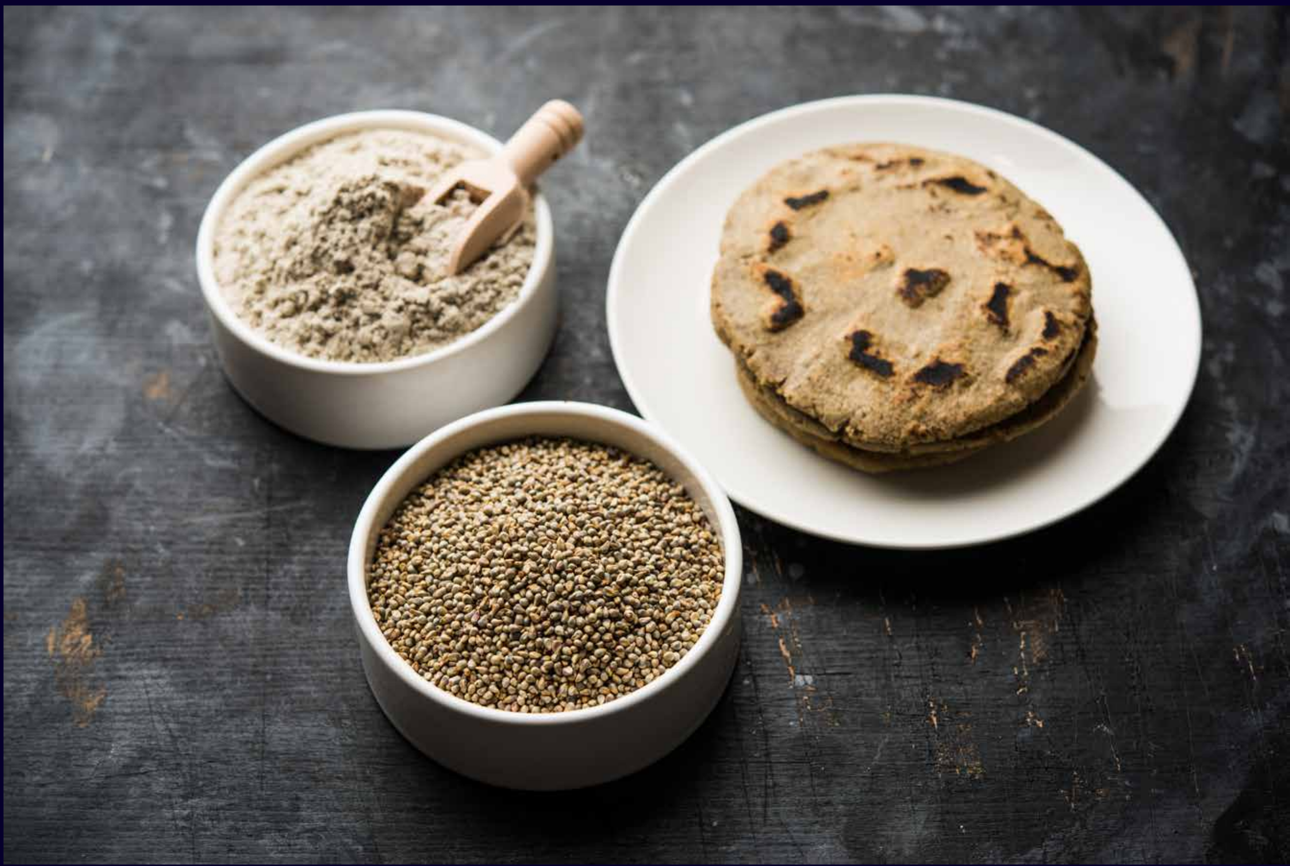
Future food security is one of the key global challenges facing society. Climate change presents significant threats to our ability to produce staple food crops – particularly in regions already vulnerable to droughts. Dr Kahiu Ngugi and his research team from the University of Nairobi and other institutions in Kenya investigated numerous varieties of sorghum – one of the world's most important cereal crops. Their aim was to find new genes that would allow the crop to withstand both drought and a common parasitic weed.

The cereal crop sorghum is a staple food for a large portion of the world's population. Within the semi-arid tropics, such as countries in east Africa, sorghum is a critical component of the diet of more than 300 million people. It is high in protein, fibre, vitamin B, and micronutrients, and it is naturally low in fat.

Droughts and poor soil fertility are two of the major drivers negatively impacting sorghum production. As droughts are occurring with greater frequency and severity due to climate change, future-proofing sorghum production is a key goal for ensuring global food security.

Additionally, stressed-out plants are more vulnerable to pests and diseases – which are also becoming unpredictable under changing climate patterns. The fungal diseases anthracnose and leaf blight, and the parasitic weed *Striga hermonthica* – commonly known as purple witchweed – have the potential to destroy whole cereal crops in eastern Africa.

Purple witchweed is one of the most devastating factors impacting sorghum production in Kenya, often disproportionately affecting sorghum plants that are already stressed by low soil fertility and poor moisture levels.



Dr Kahiu Ngugi and his team's recent research has focused on identifying sorghum varieties that are resistant to drought or purple witchweed. Several plant characteristics found in sorghum can result in drought-resistance, including a trait called 'stay-green' – referring to the delayed leaf death in these plants relative to other sorghum varieties, when grown in water-poor environments.

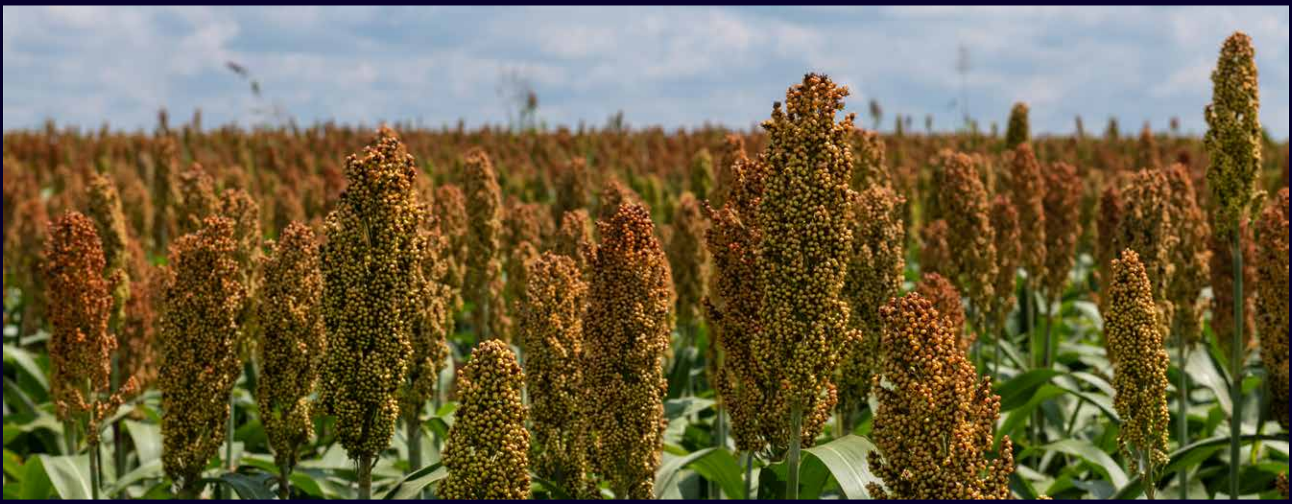
The researchers' work considers, for the first time, several different genes that produce the stay-green sorghum varieties. They suggest that finding multiple sorghum genes providing drought resistance will be important for ensuring future food security.

Purple witchweed germinates when a specific chemical produced by its host plant, sorghum, is present. The weed attaches to the roots of the host plant, inserting filaments to drain water and nutrients for its own growth and development. The weed also produces toxins that enter the sorghum plant's system. Consequently, the sorghum plant's growth is stunted, often causing total crop loss. A single purple witchweed plant can produce up to 100,000 tiny seeds that can remain dormant in the soil – waiting for an appropriate host plant for over 20 years. Thus, controlling the weed is immensely difficult and requires constant vigilance.

Conventional methods of controlling purple witchweed, such as hand-pulling the weed and rotating crops annually, are less effective than producing sorghum varieties already resistant to the weed and drought conditions. This is particularly the case for farmers who do not have the resources to implement these intensive agricultural techniques. For these farmers, crop losses can be utterly devastating to their livelihoods.

Dr Ngugi's team screened commercially improved varieties, wild relatives, and landrace varieties of sorghum for stay-green genes and resistance to purple witchweed. Landrace crop varieties are those that were domesticated historically and have been grown and improved locally for long periods of time. Sorghum was originally cultivated in Sudan and Ethiopia, and as such, these countries could house several unexploited beneficial genes in unstudied wild and landrace varieties.

Within the 44 sorghum varieties screened for drought-resistance, Dr Ngugi and his team discovered five new wild sorghum drought-resistance genes. Their research also revealed that drought-resistance helps sorghum cope better with pressure from purple witchweed attack.



This result is unsurprising because both drought and purple witchweed infestation cause sorghum plants to produce a stress hormone that triggers the closure of tiny breathing pores on the leaf surfaces. This prevents loss of moisture and helps the plant to maintain a good water-balance under drought conditions.

Drought-adapted varieties moderate this stress hormone response – helping to ensure sufficient production of sugars and nutrients to sustain plant growth and development under stressful conditions, particularly purple witchweed infestation. Similar drought and purple witchweed resistance in maize showed a 19% yield increase in these varieties over non-resistant varieties grown under stressful conditions.

The investigations revealed the genetic relationships between wild, landrace, and improved sorghum varieties, which will be useful for improving the genetic diversity of sorghum varieties through crop breeding programs. In Kenya, many sorghum landraces freely cross with nearby wild plants, demonstrating the potential for breeding efforts to create new sorghum varieties with enhanced characteristics.

However, freely crossing wild and cultivated sorghum could present problems for farmers attempting to maintain the genetics of their enhanced sorghum crops. Dr Ngugi assessed advanced molecular tools that could help track traits and crosses during breeding of sorghum crops. This technique will be beneficial to breeding programs, but will need to be refined to be efficient and cost-effective before widespread usage can be achieved.

The stay-green genes and synergy with purple witchweed resistance will need to be investigated further through the development of appropriate sorghum varieties. The new sources of the stay-green gene discovered by Dr Ngugi and his team should be urgently assessed, to ensure immediate deployment into sorghum breeding programs.

The team also revealed that the sorghum varieties with the best resistance to drought or purple witchweed were not the same varieties that produced the highest yields. Dr Ngugi suggests that plants containing resistance traits will need to be bred with high-yielding sorghum varieties to ensure that these traits will soon become commonplace in farmers' fields.

This SciPod is a summary of the papers 'Novel sources of drought tolerance from landraces and wild sorghum relatives', in Crop Science, doi.org/10.1002/csc2.20300, and 'Genotypic Variation in Cultivated and Wild Sorghum Genotypes in Response to *Striga hermonthica* Infestation', in Frontiers in Plant Science, doi.org/10.3389/fpls.2021.671984.

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