

Crop evolution in Rehovot

Much More than Falafel

Chickpea is not exactly the research object of choice for any crop geneticist. To Shahal Abbo, however, the legume provides particular opportunities to shed light on how our ancestors once became farmers.

What does the word “chickpea” evoke for you? Personally, I think of falafel or a pot filled with some sort of indefinable curry at my local Indian restaurant. It surprised me how much more there is to this crop if you take a closer look. From Shahal Abbo’s perspective, the chickpea even plays a vital part in human evolution. “In a way, chickpea domestication is fundamental to our current way of life and the modern world situation”, says the ambitious Israeli researcher who works at the Faculty of Agricultural, Food and Environmental Quality Sciences, Department of Field Crops and Genetics, at Hebrew University located in Rehovot, some 40 kilometres outside Jerusalem. His thesis might sound strange at first glance – in particular to us Europeans – but he might actually be right.

Only a few researchers

Abbo states, “Western civilisations as a whole emerged from the ancient Near East and the chickpea was one of the very first crops of the Near Eastern cradle of agriculture”. Indeed, he is referring to the so-called Neolithic Revolution that originated in this very area of the world about 10,000 years ago. There are, though, uncertainties about exactly when and where the people were inspired to change their habits – to cultivate crops in fields rather than to gather wild crops. “I am interested in Near Eastern crop evolution and the origin of agriculture”, says Abbo. Although it is not easy to publish chickpea research in high impact journals, he nevertheless focuses on this crop.

Today chickpea is mostly a third world crop. This fact, he supposes, is probably the reason why many Indian researchers work with it but only very few scientists in the industrialised nations do. However, in spite of all the difficulties, he managed to have an article published presenting a new hypothesis regarding the geographical origin of agriculture in *Science* (vol. 288, p. 1602).

Abbo and his two co-authors proposed a small core area – a region near the upper reaches of the Tigris and Euphrates riv-

ers (today south-eastern Turkey and northern Syria) – within the Fertile Crescent as the cradle of agriculture, whereas many scientists argue for the Jordan Valley and the adjacent regions of the southern Levant (present-day Israel and Jordan). The first plants grown in fields – the founder crops – consisted of the wild einkorn wheat (*Triti-*



cum monococcum), emmer wheat (*Triticum turgidum*), barley (*Hordeum vulgare*), lentil (*Lens culinaris*), pea (*Pisum sativum*), bitter vetch (*Vicia ervilia*), flax (*Linum usitatissimum*) – and last but not least chickpea (*Cicer arietinum*).

An exceptional life cycle

Abbo bases his hypothesis on the fact that all founder crops are found together and only in the small core region. The limiting factor is wild chickpea which only grows there. He thinks it is unlikely that such a rare species would be one of the founder crops if domestication had taken place elsewhere. Archaeological records also indicate that, at that time, this area had been a “centre for innovation” where a wealthy society lived.

When it comes to life cycle, the domesticated chickpea form is exceptional among the other founder crops. In the Near East, all others germinate in autumn, flower in spring and mature in summer. Whereas the wild progenitor *Cicer reticulatum* does the same, the chickpea’s crop cycle was fundamentally changed after domestication – today it is sown in spring instead of autumn. However, there is a major drawback. In summer, water is scarce in the dryland. The only source of water is the moisture stored in the soil and this has a high impact on the crop’s productivity. This is why, in the middle of the 20th century, Israeli scientists tested to see if sowing chickpea in autumn is still possible. They found out that it is and they even achieved an enhanced and stabilised yield.

Disease prevention versus freezing

Why then did ancient farmers change from autumn to spring sowing? They must have had a good reason given all the advantages of autumn sowing. In fact there is a predominant negative aspect – a fungal disease called Ascochyta blight caused by the pathogen *Didymella rabiei*. This disease can lead to complete chickpea yield loss. It mainly spreads by the spores being distributed through splashing rain – a winter weather condition in the Near East. Abbo therefore argues that the intention to avoid this disease rather than freezing temperatures or other abiotic stress caused farmers to sow chickpea in the spring. Therefore one could imagine they thought, better less yield, than a high risk of no yield at all!

If chickpea agriculture is such a complicated matter, why did people not abandon it completely? Abbo and his colleagues hypothesise that it might be due to nutritional value (*Journal of Archaeological Science*, in press). They found that compared with the wild progenitor *Cicer reticulatum*, domesticated chickpea contains considerably higher amounts of the amino acid tryptophan. They calculated that as a tryptophan source, the domesticated form is nearly twice as rich as the wild progenitor. Other scientists have shown that this amino acid increases

Shahal Abbo
with his favourite legume



ovulation rates and thus provides a better chance of having many children – an important aspect in the age of the Neolithic Revolution. Also tryptophan seems to induce satiety and can accelerate growth in humans. Abbo and colleagues think that the prehistoric farmers were aware of the nutritional aspects and therefore kept chickpea despite its agronomic difficulties.

A picture emerges...

There is, however, a gap in the archaeological records. Chickpea agriculture vanished at the very end of the pre-pottery Neolithic Age (around 8,800 BC) and first reappeared in the Early Bronze Age (post 5,750 BC). “I am also interested in the genetic basis of crop adaptation”, says Abbo. His genetic studies have enabled him to formulate a possible explanation for the gap. This theory also introduces a completely new model for crop domestication (*The Quarterly Review of Biology* 78, p. 435). He found out that wild chickpea was highly responsive to vernalisation – the requirement of low temperatures for induction or acceleration of flowering in some plants. However, the cultivated chickpea no longer requires vernalisation (*New Phytologist* 154, p. 695).

This is the picture Abbo and colleagues draw of the situation in those ancient times:

The farmers first grew wild chickpea in winter but there were problems with the pathogen *Didymella rabiei*. They then tried Spring sowing but the yields were bad due to lacking vernalisation. All this culminated in the disappearance of chickpea from archaeological records. During the gap chickpea was probably maintained on a small scale as a garden crop and people, over time, selected vernalisation-insensitive forms. According to Abbo’s studies, the genetic explanation as to why the chickpea disappeared for so long points to several genes being implicated in the vernalisation insensitivity. It seems logical that such a polygenic trait-control takes much longer to establish than the case where a variation in only one single gene accounts for the trait.

You see, chickpea is special in many ways. This exotic crop full of peculiarities allows an agrobiologist to dive deep into archaeology to see how much it can reveal about how our ancestors became farmers. If you are still not convinced that the chickpea is special, well, consider it as a peacemaker. Yes, you heard right. The conflict between the Israelis and Palestinians might seem futile, but despite the hatred intensified by the atrocities, some scientists have actually become friends. Abbo is one of them. Since 1999 he has shared a research project with the Palestinian scientist Mustafa Khamis, a physical chemist at Al-Quds University, with whom he is growing chickpea. Their goal is to increase farm production that is currently limited in both Israeli and Palestinian territories because of the dryness of the soil. This is why they are working towards re-using waste water. Khamis is developing the water purification devices and Abbo takes care of the crop issues.

An Israeli-Palestinian cooperation

In the meantime the two are funded by UNESCO’s Israeli-Palestinian Scientific Organization (IPSO) that has existed since 2004 and has, surprisingly, received many more project applications than the organisers had dreamt possible. It seems as though more and more scientists are approaching each other and following Abbo’s and Khamis’s example. Yet: “To work closely with a Palestinian academic is still a rarity in Israel. The reaction of most people is positive but there are many psychological barriers and bureaucratic ones as well”, Abbo comments. What would he wish if he could have one wish come true? “To see the Near East freed from the ongoing cycle of violence”, he says. If only more people could think and act like him. ANNETTE HUPFER