Bunyamin Tar'an is developing freeze-tolerant chickpeas.

Freeze-tolerant chickpeas on the horizon

Wild species are key to enhancing a crop's genetic diversity.

BY VANESSA FARNSWORTH

With Statistics Canada reporting that chickpea acres jumped 12.5 per cent to 541,000 in 2025 — the largest number of acres for many years — it's no wonder scientists are looking to breed varieties better adapted to tolerate those notoriously cold prairie temperatures. "We would like to give more farmers in Western Canada the opportunity to grow chickpeas as part of a four-year rotation for long-term sustainability," says Bunyamin Tar'an, the Saskatchewan Ministry of Agriculture Strategic Research Program (SRP) chair in chickpea and flax breeding. "We have peas, lentils, faba beans, common beans and now soybean heading west from Manitoba, but we also need chickpeas, which are better adapted to drier areas, including the vast majority of southwestern Saskatchewan from Swift Current south."

Chickpeas may be an important pulse crop for growers in Western Canada, especially in areas where farmers are faced with the root rot *Aphanomyces* in peas and lentils. However, Tar'an notes that the short growing season combined with the crop's intolerance to cold weather means that subzero temperatures can and do have adverse impact on chickpeas, hampering growth, reducing yields and lowering overall quality.

"With that short growing season, we are often hit with problems at two times of the year," says Tar'an. "When we seed in early May, sometimes the temperature drops just when the plants are poking up from the ground, and they die or don't recover. And because chickpea is a long growing season crop, sometimes when we have an early frost at the end of the season, the immature watery pods become frozen, and that reduces the quality."

DEVELOPING CHICKPEA VARIETIES TO WITHSTAND COLD

These things make it crucial for scientists to develop chickpea varieties that can withstand low temperatures, particularly at the seedling stage. However, the narrow genetic base of existing cultivated chickpeas hinders crop improvement efforts, something that led Tar'an to look at crop wild relatives (CWR) as a way to enhance the genetic diversity of cultivated species.

"Initially, just out of curiosity, we asked if there was anything within the germplasm of the cultivated and wild species that we have in our collection that can withstand low temperatures," Tar'an says.

One wild species, *Cicer reticulatum*, stood out for

Image courtesy of Bunyamin Tar'an.

several reasons; its genetics are closely related to the cultivated species, it tolerates suboptimal environments, it's genetically and phenotypically diverse and it's fully cross-compatible. All these things make it an excellent genetic resource for a breeding program looking to improve cultivated chickpeas.

A few years ago, Tar'an and his team at the University of Saskatchewan subjected eleven cold-tolerant wild *C. reticulatum* accessions, two cold-sensitive cultivated species (CDC Leader and CDC Consul) and a cold-sensitive check to freezing temperatures at the early vegetative growth stage for up to 24 hours under controlled conditions. After a two-week recovery period, they compared the responses.

"We were focusing on the seedling stage because once plants are hit by low temperatures during that stage, some won't recover, which then requires farmers to reseed. If they don't, they'll get patchy fields and that will be a problem. The crop won't be uniform, and weeds will move in."

None of the plants from the commercial varieties survived that initial experiment. The four most cold-tolerant wild species and both cultivated species were further evaluated by subjecting them to a cold acclimation period, then both sets of plants (acclimatized and non-acclimatized) were exposed to freezing temperatures, then returned to control conditions for recovery and assessed after two and three weeks.

"We initially subjected the plants to normal growing conditions, then reduced the temperature from 22 C during daylight down to 4 C for one week, which led the plants to acclimatize," says Tar'an. "Then, we reduced the temperature to -6 C for 24 hours. After that, we returned it to normal conditions and then looked at the regrowth of the plant."

Only the acclimatized wild species survived the freezing temperatures, and two of those (CudiA_152, Kesen_075) had the highest degree of cold tolerance, not only surviving but also developing new roots. Selected plants from an F2 population developed from a cross between CDC Consul and Kesen_075 also proved to be cold tolerant. Further analysis provided insights into potential freezing stress response mechanisms.

"During that time period, from the acclimatization and the cold reaction, we collected the RNA — so we could examine what genes are being expressed — and we compared those with plants grown under normal conditions," Tar'an says. "What were the differences? What triggered this response? From there, we made some hypotheticals based on pathways that are well known in other species. Was there any similarity to what we have in chickpeas?"

STRIKING A BALANCE

Tar'an's team identified ten significant quantitative trait

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loci (QTLs) distributed across five chromosomes in wild chickpea, all of which are associated with tolerance to freezing stress. They also identified functional candidate genes within these QTL regions that are believed to play vital roles in mechanisms related to cold tolerance. These findings paved the way for the targeted breeding strategies now being used to make the crosses and selections with the goal of developing chickpeas that are cold tolerant without sacrificing yield, seed quality or other factors necessary for commercialization.

"When we make a cross with a wild variety, the seed quality and how it looks isn't necessarily appealing to consumers," Tar'an says. "So then I have to bring back that desirable characteristic while maintaining the plant's tolerance to cool temperatures."

Tar'an and his team are making significant progress. On the material they've tested so far, the recovery rate following that critical 20- to 24-hour freezing period has been 100 per cent, a huge improvement compared to currently available commercial varieties, most of which fail at six hours. The goal now is to identify new lines that strike a balance between improved cold tolerance and other desirable characteristics.

"It's about compromise. That's how the biology works," says Tar'an. "For me, as a researcher, it's about how this one factor and the others are interconnected within the plants. Where is that connection between two factors at the genetic level? Is the same gene controlling both components or are they controlled by separate genes that are close together? And if they are close together, can we separate them?"

While initial scientific studies were conducted indoors in a controlled environment designed to mimic typical growing conditions in Saskatchewan, large-scale breeding takes place in the field where temperatures can be unpredictable.

"That's been a challenge. The larger breeding scale can't be done indoors. We have to do the growing in the field, so we seed early and record the temperatures, but for the past few years we've been seeing warmer early seasons," says Tar'an, noting this has slowed down progress. "Although it has not been as fast as I would have expected, we're making definite progress crossing the wild material with the cultivated lines."

Tar'an estimates it will take several more years of field testing to ensure those promising varieties perform stably at low temperatures before they're ready for commercialization. He's optimistic that, once that happens, farmers will be able to breathe a little easier.

"It's not like chickpeas will ever become cold tolerant down to -20 C, but at least the crop will be able to withstand -6 C for 20 hours and be able to regrow," he says. "That may set growers back a little, but their fields aren't going to need reseeding."