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Combating micronutrient malnutrition: lessons from superfood sea-buckthorn for improvement of wheat

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Since 1990s, climate shocks have doubled especially for countries that are already vulnerable to climate change like Pakistan. Without proactive climate adaptation and mitigation, food

insecurity is expected to escalate, threatening staple crops like wheat. It is believed that as Harvest Index has reached 60% of its limit, yield cannot be achieved further. Further improvement in yield can, however, be achieved through increasing the photosynthetic capacity and water use efficiency.

Climate change not only affects crop productivity but also compromises crop quality. Malnutrition especially micronutrients (iron, zinc, and vitamin C) deficiency in cereal consuming group affects more than two billion people specially in countries like Pakistan. Wheat, Pakistan's dietary staple, currently supplies 72% of daily calories. However, most of the Fe and Zn are stored in the aleurone layer of the grain that is lost during milling. Furthermore, these nutrients are bound to phytate, making them bio-unavailable. Consequently, about 60% of the global population lack iron and more than 25% is Zn deficient. Similarly, vitamin C deficiency affects nearly half of the population in low to middle income countries (LMIC), including Pakistan. This "hidden hunger" arises from the lack of food diversity, leaving large proportions of population to malnutrition. These nutrients are also important for metabolic processes and their deficiency impairs body growth, brain functionality, and immune system.

One of the solutions is diversifying the food basket with the nutrient-rich underutilized species like sea buckthorn, which can grow in marginal lands without competing with the staple crops. In

this research, the researchers evaluated wheat alongside sea-buckthorn (*Hippophae rhamnoides* L.), comparing their iron, zinc, vitamin C, and anti-nutritional compounds (phytic acid) as well as leaf functional traits for climate resilience. Iron content was found six times higher (200 mg kg^{-1} on an average) in sea buckthorn compared to wheat (38 mg kg^{-1}). However, Zn content was four times higher in wheat (29.5 ± 4.2 mg kg^{-1}). Sea buckthorn also had high vitamin C content (40 to 595 mg/100g). Moreover, for these nutrients to be biologically available and to improve their absorption in human body, PA:Fe should be <1, while PA:Zn. The study thus concluded that micronutrients availability is higher in sea-buckthorn as indicated by the low PA:Fe/Zn ratio (<0.8) compared to wheat.

The study also highlighted leaf traits in wheat and sea buckthorn that enhance water use efficiency and photosynthetic capacity, essential traits in adapting climate change. The erratic climate patterns demand phenotypic plasticity to adapt under increasing heat and drought episodes. An ideotype of wheat with differential leaf canopy for light interception, improved photosynthesis, high drop rolling efficiency to facilitate air moisture diversion into the rootzone, longer prickle hairs on leaf surface, and lower stomatal density can be a strategic approach to enhance water use efficiency in grasses like wheat. The study identified diversity of three leaf traits viz leaf angle, groove type, and leaf rolling, along with leaf wettability across five different locations of sea-

buckthorn growing regions of Gilgit, Pakistan. Sea-buckthorn leaves were found to be hydrophilic with less drop rolling efficiency with few exceptions in low altitude regions where hydrophobic leaves were also found. Overall, it was concluded that an assembly of leaf traits with semi-droopy to droopy leaves, light leaf groove, 5-25% inward leaf rolling, moderate leaf hair density along with hydrophobicity and lower contact angle hysteresis can be helpful in sea-buckthorn under climate change scenario.

This study highlights the potential of local sea-buckthorn as a nutritious, climate-resilient food source for Pakistan. High-nutrient sea-buckthorn berries could become a part of daily diets through products like fortified wheat-sea-buckthorn flour, antioxidant-rich jams, vitamin C teas, and cereals. These initiatives not only provide nutritional benefits but also offer income opportunities for rural communities, particularly in the Gilgit-Baltistan region.