Remobilization of Mineral Nutrients from Peach (Prunus persica L. Batsch) Foliage during Senescence

Article *in* Journal of the Indian Society of Soil Science · January 2019

DOI: 10.5958/0974-0228.2019.00051.3

Sovan Debnath
ICAR-Central Institute of Temperate Horticulture, Mukteshwar

Anil Kumar
ICAR-Directorate of Mushroom Research, Chambaghat, Solan (HP)

Journal of the Indian Society of Soil Science, Vol. 67, No. 4, pp 465-467 (2019)
DOI: 10.5958/0974-0228.2019.00051.3

Short Communication

Remobilization of Mineral Nutrients from Peach (*Prunus persica* L. Batsch) Foliage during Senescence

Sovan Debnath*, Arun Kishor, Raj Narayan, Anil Kumar and Desh Beer Singh[1]
ICAR-Central Institute of Temperate Horticulture, Regional Station-Mukteshwar, Nainital, 263138, Uttarakhand

Remobilization of nutrients is frequently associated with foliage abscission but received much less attention in deciduous fruit crops. Analysis of mature and senescent leaves of peach (*Prunus persica* L. Batsch) revealed remobilization of several nutrients namely, nitrogen (N), potassium (K), copper (Cu), manganese (Mn), zinc (Zn)and boron (B), although with different efficiencies. In contrast, nutrients such as calcium (Ca), phosphorus (P), magnesium (Mg) and iron (Fe) are accumulated in the senescent leaves. Recycling of nutrients through leaf fall can decrease considerably the need for fertilizer inputs.

Senescence is an age-dependent process of degeneration and degradation, and affects the cells or the tissues and culminates into death (Sarwat 2017). Each plant species has an inbuilt ‘plant programmed’ pattern of leaf senescence (Hill 1980). For example, leaves of annual plants undergo sequential senescence, while leaves of deciduous trees undergo synchronous senescence. The metabolic changes that take place during leaf senescence include hydrolysis of proteins, nucleic acids, lipids, and pigments which are synthesized during the active growing phase (Watanabe *et al*. 2013). The degradation of these macromolecules is very essential to liberate transportable plant nutrients which are then remobilized to storage organs (*e.g.*, trunk, root *etc*.) or growing tissues of the plants. An understanding of the remobilization of nutrients within plants is indispensable in elucidating the overall nutrients behaviour in plants, and in improving the usefulness of diagnostic tests in mineral nutrition of plants.

Nutrient remobilization, a key process in internal nutrient conservation in deciduous perennials, is frequently associated with foliar senescence, and contributes to nutrient use efficiency (El-Jendoubi *et al*. 2013; Sarwat 2017). Deciduous plants (*e.g.*, peach) store nutrients to buffer a transient lack of nutrient uptake by roots during winter, which are remobilized from the trunk during spring. Remobilized nutrients remain very useful in bud–breaking at the beginning of the next growing season and to begin rapid and sustained growth (El-Jendoubi *et al*. 2013). General appraisals of the remobilization of essential nutrients during plant senescence in deciduous perennials are relatively scarce, being only well- documented on annual field crops during crop growth. This study intended to assess the extent of remobilization of mineral nutrients during leaf senescence in peach (*Prunus persica* L. Batsch) crop.

A two year (2015 and 2016) experiment was conducted on a 9 to 10–year–old rainfed peach (*cv.* Red June) orchard at ICAR–Central Institute of Temperate Horticulture, Regional Station–Mukteshwar (29°28' N, 79°39' E, 2280 m asl) in Uttarakhand, India, located at the ridge on the southern edge of the North–Western Himalaya. The trees were planted on four adjacent terraces (slope 33–34%) as double row within a terrace (50–55 × 6 m) and spaced 1.0 m (intra–plant) × 4.0 m (between row) apart. The soil is Typic Haploudoll (USDA Classification) which is slightly acidic (pH 5.6–5.9) and sandy loam to loamy sand in texture (clay 12–16%).

Leaf samples were taken at two different times along the season to assess the foliage nutrient status. Fifty mid–shoot mature leaves (ML) from fruiting spurs were sampled at 8 weeks after full bloom (in May), considered as optimum sampling time, from five representative peach trees per terrace. In September, litter-traps (1 m^2; two per terrace) were placed beneath the crowns of trees to recover the senescent leaves (SL) for four consecutive months (September–December). Month-wise total number of fallen leaves was recorded and oven–dried sub-

*Corresponding author (Email: Sovan.Debnath@icar.gov.in)
[1]Present address: ICAR-Central Institute of Temperate Horticulture, Srinagar, 190007, Jammu and Kashmir

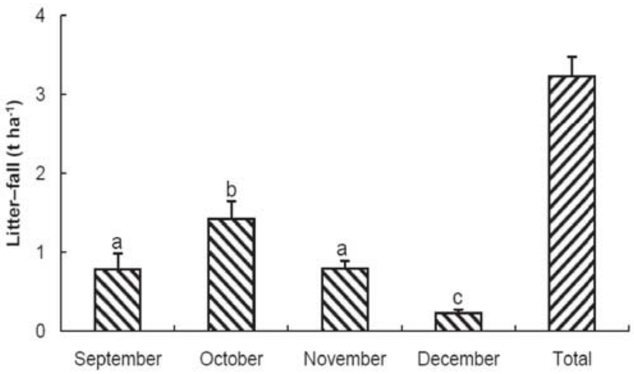

Fig. 1. Extent of litter–fall observed from September to December. Oven–dried sub-samples of leaves (n= 80) per month were weighed to estimate the litter–fall in peach. Columns followed by letter in common do not differ significantly ($p \leq 0.05$) based on Duncan's multiple range test. Bars indicate standard error

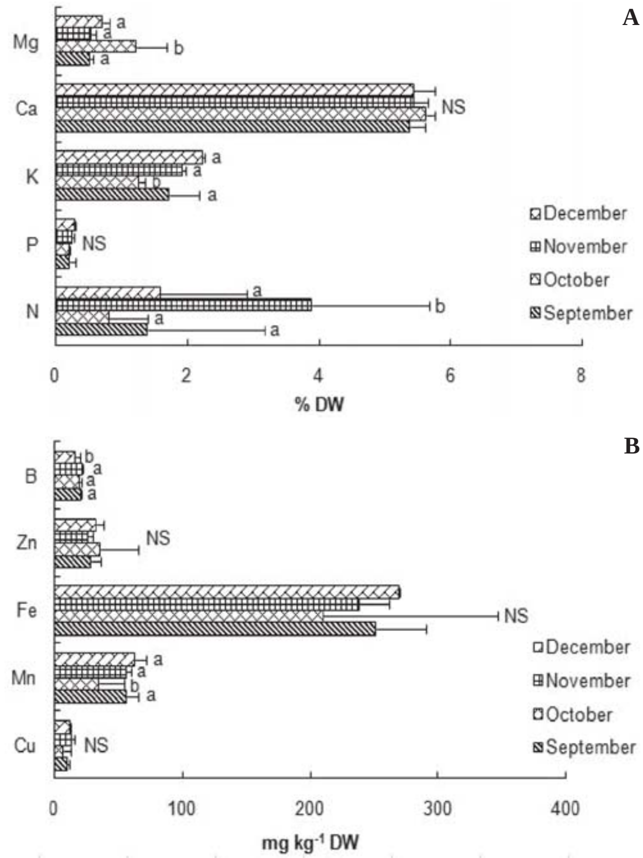

Fig. 2. Monthly variation in concentration of macronutrients (A) and micronutrients (B) in the trapped senescent leaves. Columns followed by letter in common do not differ significantly ($p \leq 0.05$) based on Duncan's multiple range test; NS–non-significant. Bars indicate standard error (n= 80)

samples of 10 leaves per trap were weighed to estimate the litter–fall in peach.

Mature (ML) and senescent leaf (SL) samples were washed, mineralized and analyzed using standard procedures (Debnath *et al*., 2015a,b; Debnath *et al*., 2017). Nitrogen, and P and B were analyzed by the micro-Kjeldahl method and spectrophotometrically, respectively. Potassium was measured by flame emission spectroscopy, and Ca, Mg, Fe, Mn, Cu and Zn were measured by atomic absorption spectrophotometry. Concentrations were expressed as % DW (dry weight) for macronutrients (N, P, K, Mg and Ca) and as mg kg^{-1} DW for micronutrients (Fe, Mn, Cu Zn and B). Statistical analysis was performed using SPSS 16.0 Windows version.

October month accounted for the maximum litter–fall (1.43 t ha^{-1}), which was significantly ($p \leq 0.05$) higher than other months (Fig. 1). December month registered the lowest quantity of litter–fall (0.23 t ha^{-1}), and a total of as much as 3.23 t litter ha^{-1} was recorded during the leaf–shedding period. In general, mineral nutrient concentration in the abscised leaves did not vary significantly ($p \leq 0.05$) between the observed months (Fig. 2). Highest leaf abscission in October caused a decline in mineral concentration (N, P, K, Cu, Mn, and Fe), which possibly indicated that nutrient remobilization from the peach foliage could elevate in October.

As a result of remobilization, leaf content of N K, Cu, Mn, Zn and B decreased significantly ($p \leq 0.05$) in the SL over the ML (Fig. 3). Remobilization efficiencies were 59% for N, 39% for K, 61% for Cu, 53% for Mn, 40% for Zn and 11% for B. Conversely, the concentration of P, Ca, Mg and Fe increased in SL (Fig. 3). It has been found previously that remobilization of P, Ca, Mg and Fe did not occur at fall in deciduous tree species and fruits (Hagen-Thorn *et al*., 2006; El-Jendoubi *et al*., 2013), and were largely lost. The storage of P and Mg differs greatly from N, as these nutrients are mainly stored in vacuoles under inorganic forms. This would provide an argument to suggest that their remobilization could be independent of senescence in peach. If this is so, it seems possible that a leaf could act as a source of one nutrient while behaving as a sink for the other. Boron and Mn usually show low phloem mobility (White 2012), though these appeared to be remobilized from peach foliage. This follows the findings that, under specific induction condition, leaf remobilization of Mn and B may occur, and can be leached out of leaves by water (Maillard *et al*. 2015).

Overall, primary and micronutrients appeared to be most efficient at remobilization, while secondary nutrients were the least efficient in peach trees. This

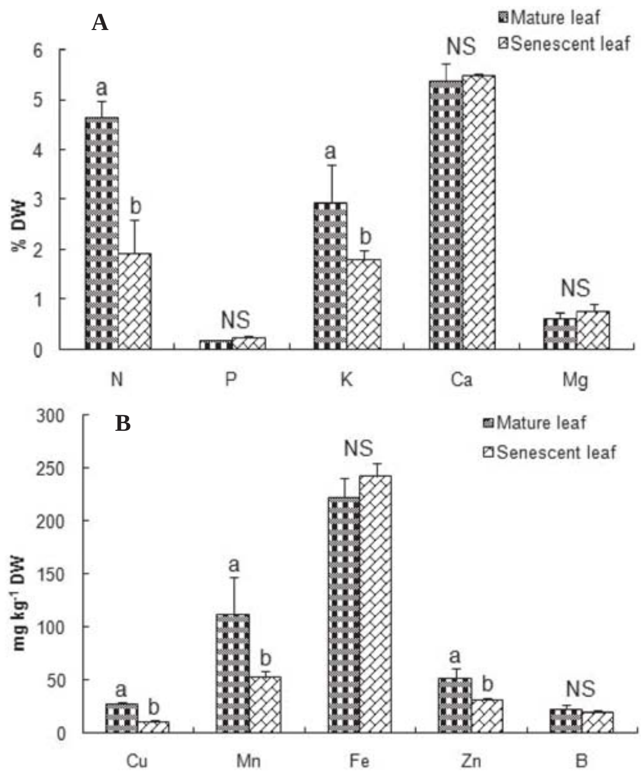

Fig. 3. Change in concentration of macronutrients (A) and micronutrients (B) observed from mature leaf (ML) to senescent leaf (SL). Columns followed by letter in common do not differ significantly ($p \leq 0.05$) based on Duncan's multiple range test; NS– non-significant. Bars indicate standard error (ML: n= 200; SL: n= 320)

ecophysiological pattern is, perhaps, also modulated by the ability of peach trees to move nutrients through phloem sap. The pattern and extent of remobilization of mineral nutrients in peach trees at fall reported in this study could help in improving optimization of the fertilization rates.

Acknowledgments

This study was supported and funded by the project 'Characterization of soil and nutritional survey in major apple and peach growing areas of Uttarakhand (Project Code–IXX10603)'. We thank Shri Mahesh Nogiya and Shri Ram Singh for their generous help in leaf sampling and chemical analysis.

References

Debnath, S., Pachauri, S.P. and Srivastava, P.C. (2015a) Improving use efficiency of applied phosphorus fertilizer by zinc fertilization in *Basmati* rice-wheat cropping system. *Indian Journal of Agricultural Research* **49**, 414-420.

Debnath, S., Narayan, R., Kumar, A., Attri, B.L. and Kishor, A. (2015b) Deficiency of magnesium in maize (*Zea mays* L.) induced by high potassium level in a micaceous soil of Kumaon region of Uttarakhand, India. *Journal of Applied and Natural Science* **7**, 903-906.

Debnath, S., Attri, B.L., Kumar, A., Bhatt, S.C., Kishor, A., Narayan, R. and Singh, D.B. (2017) Relationship among different forms of soil potassium and availability as influenced by the contrasting management practices in apple (*Malus domestica* Borkh.) orchards of Kumaon region. *The Bioscan* **12**, 477-484.

El-Jendoubi, H., Abadía, J. and Abadía, A. (2013) Assessment of nutrient removal in bearing peach trees (*Prunus persica* L. Batsch) based on whole tree analysis. *Plant and Soil* **369**, 421-437.

Hagen-Thorn, A., Varnagiryte, I., Nihlgård, B. and Armolaitis, K. (2006) Autumn nutrient resorption and losses in four deciduous forest tree species. *Forest Ecology and Management* **228**, 33-39.

Hill, J. (1980) The remobilization of nutrients from leaves. *Journal of Plant Nutrition* **2**, 407-444.

Maillard, A., Diquélou, S., Billard, V., Laîné, P., Garnica, M., Prudent, M., Garcia–Mina, J.M., Yvin, J.C. and Ourry, A. (2015) Leaf mineral nutrient remobilization during leaf senescence and modulation by nutrient deficiency. *Frontiers in Plant Science* **6**, 317.

Sarwat, M. (2017) Leaf senescence in plants: nutrient remobilization and gene regulation. In *Stress Signaling in Plants: Genomics and Proteomics Perspective* (M. Sarwat *et al*., Eds.), Springer, Switzerland, pp. 301-316.

Watanabe, M., Balazadeh, S., Tohge, T., Erban, A., Giavalisco, P., Kopka, J., Mueller-Roeber, B., Fernie, A.R. and Hoefgen, R. (2013) Comprehensive dissection of spatiotemporal metabolic shifts in primary, secondary, and lipid metabolism during developmental senescence in Arabidopsis. *Plant Physiology* **162**, 1290-1310.

White, P. (2012) Long-distance transport in the xylem and phloem. In *Marschner's Mineral Nutrition of Higher Plants* (P. Marschner Ed.), Elsevier, Berlin, pp. 49-70.

Received 8 April 2019; Accepted 2 August 2019