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Water and Nutrient Use Efficiency in Crop Rotation

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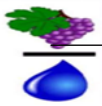
Agronomic and physiological terms of water use efficiency

Agronomists define it in terms of the units of water used per unit of dry matter produced, often using total water lost by both evaporation and transpiration.



$$\frac{\text{Crop yield}}{\text{water used in evapotranspiration } (m^3)}$$

Physiologists are more likely to discuss it in terms of photosynthesis, expressed as milligrams of CO2 per gram of water. It's an important attribute that describes the efficiency of crop plants to use available water for carbon fixation.

Water-use efficiency (WUE) in Crop rotation

Crop rotation is the practice of growing a series of dissimilar type of crops in the same space in sequential seasons.

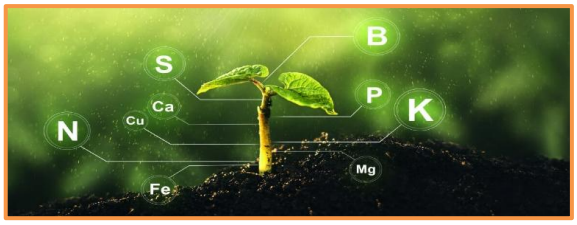
Impact of water-use efficiency on crop rotation

- ✓ **Denser plant canopy –** cover soil surface, reduce soil evaporation and enhance WUE.
- ✓ **Rotation of crop** with deep root followed by fibrous root enhance WUE (limited irrigation condition).
- ✓ **Canopy architecture –** erectophile canopies (leaf erect) have more light penetration than planophile **(**horizontal leaf).
- ✓ **Erect leaves have** better WUE than semi-erect or droopy leaves**.**
- ✓ **Root traits:** deep roots, high root density, wide xylem diameters and long root hair enhance the water and nutrient uptake**.**
- ✓ **Root hydraulic properties:** cereals (only root tips are involved in water and nutrient uptake) so root branching is important here.
- ✓ **legumes (**whole roots are involved) root length is important
- ✓ Irrigating crop at **critical growth stage - improve WUE.**
- ✓ **Automated** sprinklers and highly efficient drip irrigation enhance the WUE (less evaporation losses).
- ✓ Suppress habitual weeds of mono-cropping.
- ✓ **Optimised Water Uptake**: More effective water use is ensured by diverse root systems that can reach water from varying soil depths.
- ✓ **Better Soil Structure**: Crops with deep roots delve deeper into the ground, forming channels that enhance drainage and water infiltration. Crops with shallow roots use water from the top soil layers.
- ✓ **Decreased Water Loss:** By using cover crops in rotation systems, soil evaporation and surface runoff can be reduced.
- ✓ **Improved Plant Health**: Plants that have a balanced diet and are less susceptible to pests and diseases use water more effectively.

- ✓ Increased Soil Organic Matter: The soil's structure and ability to retain water are enhanced by the diverse organic matter that crop residues from various plants contribute.

Nutrient use efficiency

A measure of increase in crop yield obtained per unit nutrient applied. It's the different response of crop or genotypes in yield when grown in nutrient deficient soils (George *et al*., 2012).



Nutrient use efficiency has expressed at three different levels.

Leaf level – potential maximum photosynthetic rate for certain nutrient content
Plant level – ratio of biomass produced to the total nutrient uptake
Crop level – ratio of total biomass produced to the amount of nutrients available for uptake from soil (Ewel and Hiremath, 1998).

Impact of nutrient use efficiency on crop rotation

- ✓ Rotation of legumes with non-legumes can promote plant growth
- ✓ Symbiotic nitrogen fixation by PGPR (Plant growth promoting bacteria)
- ✓ production of phytohormones (Auxins, Gibberellins, Cytokinins)
- ✓ Production of siderophores (iron in iron-limited soils)
- ✓ Symbiosis of rhizobia and VAM fungi with legumes improved N and P uptake.
- ✓ Smoothering crops and cover crops reduce soil erosion
- ✓ Potato- Wheat- Oil flax- Wheat (higher soil organic matter)
- ✓ Wheat-forage crop rotation
- ✓ Annual grass-clover and Lucerne
- ✓ Oil flax- Mono-cropping (soil nutrient depletion, build-up of pest and disease)

Crop rotation improves nutrient use efficiency by the rotation of nutrient depleting crop with replenishing crop.

Legumes (e.g., soybeans, peas) fix atmospheric nitrogen, enriching soil for nitrogen-demanding crops like cereals.

Reduced Nutrient Losses: By minimizing the need for nitrogen fertilizers, legume-based rotations can reduce nutrient losses through leaching and runoff, leading to more efficient nutrient utilization

Improved Nutrient Cycling: Diverse Root Systems: Different root depths and structures improve soil aeration and drainage, boosting soil microorganism activity essential for nutrient cycling (e.g., mineralization and nitrification).

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