MANAGEMENT STRATEGIES FOR WATERLOGGED SOILS IN AGRICULTURE

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By surveying the whole world it has been found that submerged and waterlogged soils covers about 5 to 7% of earth land surface; and global waterlogged soil is approximately 700 to 1000 million ha. Globally, tropical swamps, rice fields and floodplains correspondingly account nearly 14, 12 and 10% of total waterlogged area. Odisha, West Bengal, Bihar and Uttar Pradesh have maximum waterlogged soil in India and overall total area estimated one million hectare.

WATERLOGGED SOIL

Soils saturated with water for a long time that give the distinctive gley horizons resulting from oxidation-reduction processes. A profile of waterlogged soil contains (a) free surface water, (b) a partially oxidized layer with redox potential 400 mV or more, and (c) a permanently reduced layer with bluish green mottling (Robinson, 1949).

MANAGEMENT STRATEGIES

Raised Bed Farming: As waterlogging creates anaerobic environment plant roots can't survive in those conditions, but in raised bed cultivation practices an artificial aerobic condition created by cultural practices. If plantation crops planted on raised flat bed and rice on slope of the raised bed, gives greater results in-terms of yields. As physical manipulation of soil and raised bed forming creates favorable conditions for higher hydraulic conductivity, and decreases soil bulk density that result greater root penetration and good drainage. ICAR-Indian Institute of Soil Science also engaged with management of water logged agricultural lands for various crops and cropping systems (Figure 1).

Figure 1 Raised bed system in the research field of ICAR-IISS Bhopal (a) Soybean (b) Maize

Drainage:

a. **Surface drainage**: Surface drainage is an integral part of agriculture in humid and sub humid regions. In monsoon climatic conditions, it is essentially required even in the arid and semi-arid regions. Conventional surface drainage consisting of main, sub-mains or collectors. These drains must be supplemented by some kind of surface drainage systems, which are under the direct control and supervision of the farmers. Innovative surface drainage technique such as on-farm ponds; modifications in land configuration must be introduced as alternative options for surface drainage.

b. **Sub-surface drainage:** Sub-surface drainage mostly practiced in areas with higher ground table. Sub-surface drainage lowers the water table or perched water and ensures a suitable environment in the root region where waterlogging occurs. These drainage systems consist of open and pipe drains with variable drain depth and spacing. The systems are more effective in areas where the sub-soils are sufficiently stable and not exhibiting characteristics of hostile sub-soils such as sodicity. Usually, the type of drain to be installed depends on topography, soil characteristics and rate of drainage required. Managing waterlogging with horizontal tile drainage systems (using a combined drainage system with tube wells plus horizontal drainage systems) is more beneficial in maintaining the water table within the desirable depths.

c. **Bio-drainage:** Bio-drainage may be defined as "pumping of excess soil water by deep-rooted plants using their bio-energy." The bio-drainage system consists of (i) fast growing tree species, (ii) larger canopy area, and (iii) plants with luxurious water consumption and higher transpiration rate. As for example, *Syzygium cumini, Pongamia pinnata, Terminalia arjuna, Casurina glauca, Eucalyptus tereticornis* are some most effective and used bio-drainage plants (figure 2). As curative (for waterlogged areas) and preventive (for potentially waterlogged areas) measures bio-drainage is most useful technique.

FACTORS CONTROLLING EFFECTIVE BIO-DRAINAGE

There are four factors that can be manipulated when designing agroforestry systems for controlling dry-land salinity and waterlogging. These are:

- The area planted: Area of plantation is positively correlated with potentiality of bio-drainage.
- The arrangement of the trees: Trees should be planted with spacing that enhances total canopy coverage, which enhance the total amount of transpired water through leaves.
- Their location within a catchment: Plantation of bio-drainage plant surrounding the waterlogged areas gives better results rather than within waterlogged areas.
- The tree species selected: Tree species having fast growth rate, deep root penetration, larger canopy coverage, higher transpiration rate should be selected for bio-drainage.

Figure 2 Commonly used bio-drainage plants

CROP MANAGEMENT

Crop management options to increase crop water use and decrease the incidence of waterlogging includes early sowing and higher sowing rates. Early sowing of wheat varieties showed better performance due to reduced risk of waterlogging damage through de-watering of the soil profile and avoiding waterlogging at vulnerable early growth stages. Wheat, barley and rapeseed plants were less affected by early waterlogging (vegetative stages) than late (reproductive stages). Early sowing can also avoid late season terminal waterlogging events. Early crop vigor can be another important trait for waterlogging tolerance in the field. Tillering and reproductive stages are crucial for waterlogging tolerance in crops such as wheat and barley. Reduced nitrogen uptake is one of the main effects of waterlogging stress in crops. Early vigor may be linked with increased uptake of nitrogen. However, under normal conditions seedling growth rates can also vary with genotypic differences.

NUTRIENT MANAGEMENT

Nutrient deficiency is one of the major effects of waterlogging on plants, resulting in reduced photosynthesis and net carbon fixation ultimately leading to a reduction in growth and therefore yield. Application of essential nutrients will assist in mitigating the negative effects of abiotic stresses like waterlogging leading to increased productivity. The use of enhanced-efficiency N fertilizers such as slow-release or controlled-release (SR/CR) fertilizers play an important role in improving plant growth and development under waterlogged conditions. Potassium fertilizer has also been reported to ameliorate the detrimental effects of waterlogging in several crops including sugarcane, rapeseed and cotton. Exogenous application of various phosphorus (P) sources such as dairy cow manure (DCM) and meat and bone meal (MBM) is effective for producing optimum yields in P-deficient conditions during a wet growing season. Application of farmyard manure also significantly increased grain Fe, Zn, Cu concentration of paddy under flooded conditions. Similarly, foliar application of boron has been reported to increase overall plant growth and alleviate deleterious effect of waterlogging of maize. Appropriate application methods, nutrient types, timing and rate should be considered to avoid the negative effect of tissue toxicities (e.g., manganese) and nutrient imbalance on soil ecology. Application of nitrogen fertilizer during or immediately following waterlogging was less effective than pre-waterlogging due to inefficient nutrient ion absorption capacity of impaired roots, high leaching risks in the wet soils and at the late growth phase additional fertilizer applied could cause excessive vegetative growth and harvesting problems of plant. Therefore, this strategy has limitations on a large-scale as the damaging effects of waterlogging can only be partially alleviated by the addition of fertilizers because of the reduced capability of roots to absorb nutrients.

CONCLUSIONS

Waterlogging can be efficiently regulated by modulating land shapes, mechanical as well as bio-drainage, and controlled irrigation measures. Tolerant or resistant varieties and proper nutrient management would be much more effective for better survival of agricultural crops in waterlogged soils.

REFERENCES

Robinson, G. W. 1949. "Soils, Their Origin, Constitution, and Classification,3rd ed. Murby, London.

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