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Physiological Factors of Dry Land Crop Production

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Abstract

Soil moisture is the most limiting factor in dry land farming. Understanding the physiological processes that occur during moisture stress is necessary to ameliorate the stress effects either by management practices or by plant improvement. The major physiological principles that affect dry land crops are as follows: Soil moisture stress, Effect on photosynthesis, Assimilate saturation, Respiration, Metabolic reaction, Hormonal relationships, Growth and Leaf area development and reproduction and yield.

Introduction

Inadequate or uneven distribution of rainfall, late onset and early cessation of rainfall, prolonged dry spells during the crop period, Low moisture retention capacity of the soil, drought and phenological changes in crops.

Moisture Loss Spectrum

Evaporation losses from soil surface, Transpiration loss from plant surface and combined effect of evapotranspiration loss.

Major Ways to Overcome Moisture Loss

Suitable selection of drought resistant crops, using different types of mulches, using different types of antitranspirants, wind breaks and shelter belts, adopting efficient weed control methods, selective tillage practices for dry land areas like zero tillage, minimum tillage, summer ploughing, water harvesting and supplemental irrigation and watershed management.

Effect of Moisture Stress on Physiological Aspects

Moisture stress does not affect all aspects of plant growth and development equally. Some processes are highly susceptible while others are less affected. But finally, the yield of the crop is reduced by the integrated result of these effects of stress on photosynthesis, respiration, nutrition, growth and development.

Effect on Photosynthesis

Photosynthesis is reduced by moisture stress due to reduction in photosynthetic rate, chlorophyll content, leaf area and increase in assimilate saturation in leaves. Similarly the translocation of assimilates is affected due to water stress in plants.

The Photosynthetic process: the photosynthetic process i.e., entry of carbon dioxide into the leaf and photochemical reactions are affected by moisture stress. At moisture stress,

stomata closure is a mechanism to reduce the transpiration losses. Due to this, CO_2 entry is also reduced by mesophyll cells, and ultimately reduced photosynthetic rate mainly due to stomatal resistance and closure.

Assimilates Saturation: Translocation of assimilates is affected by water stress. Due to assimilate saturation, photosynthesis is reduced.

Effect on Respiration

During the mild water stress the respiration rate in plants increases, whereas during severe water stress the rate of respiration is decreases in plants. More severe drought lowers water content and respiration. In wheat CO_2 output is more in early stages of drought before there is any measurable change in water content. C_4 , CAM plants have less respiration loss than C_3 plants in dry land farming.

Effect on Metabolic Reactions

Almost all metabolic reactions are affected by water deficits. Severe water deficits cause decrease in enzymatic activity, e.g., Nitrogenase enzyme activity in legume crops. Accumulation of amino acids and sugars takes place under moisture stress. Proline, an amino acid, accumulates whenever moisture stress occurs. Its accumulation is more in later stages of plants and it is considered as a good indicator of moisture stress.

Effect of Protoplasmic Dehydration

When dehydration is severe tissues become desiccated, protoplasm viscosity increases and leads to rigid and brittle nature of plants.

Effect on Anatomical Changes

Periodical water stress develops decrease in size of plant cells and decrease in size of intercellular spaces, thicker in size of cell wall and greater development of mechanical tissues and increase in number of stomata per unit leaf area.

Effect on Nutrient Uptake

Moisture stress affects nutrient fixation, NPK uptake and assimilation of nitrogen. Nitrogen fixation by leguminous plants is reduced by moisture stress due to reduction in activity of nitrogenase enzyme in leg haemoglobin in root nodules. Nutrient uptake is the product of nutrient content and dry matter production. Moisture stress may or may not reduce nutrient content, but reduces dry matter production and nutrient uptake of plants. Severe moisture stress affects N fixation, N uptake and assimilation of N and reduction of N fixation by legumes, there is an inverse relationship between specific nodule activity and stomatal resistance and the nitrogenase enzyme activity is also reduced. Ultimately the moisture stress reduces the dry matter production and nutrient uptake. NPK uptake is reduced and N, P deficiency increases due to increase in stomatal resistance

and stomatal closure.

Effect on Growth

Due to moisture stress the rapidly growing plant organs gets affected. The expansion of cells and cell division is reduced. The decrease in growth of leaves, stems and fruits were noticed. The germination, leaf area development, leaf expansion and root development were affected. The assimilate accumulation in leaves leads to leaf turgor and leaf activities.

Effects on Development

Moisture stress delays maturity, moisture stress before flowering increases the duration of the crop, similarly moisture stress after flowering reduces the duration of the crop, the stress degree days approach is used for predicting the crop production, which considers light, temperature and water levels in calculating maturity date of the crop.

Effect on Reproduction and Grain Growth

Moisture regime during flowering and grain development determines the number of fruits and weight. For many crop plants especially cereals, the moisture stress at panicle initiation is critical. Anthesis is another important moisture sensitive stage in crops. However, vegetative and grain filling stages are less sensitive to moisture stress.

Effect on Yield

The effect of water stress on yield depends largely on what proportion of the total dry matter is converted into useful material to be harvested. Stress during grain development reduces the yield and the moderate stress on crop growth does not have adverse effect on yield. Moisture stress influences the pod abortion in legumes and decreases the leaf sucrose and starch concentration, in case of forage crops and leaf tobacco the leaf growth were affected. The crops like sugar beet, potato are highly sensitive to moisture stress and the yield is affected drastically. In case of cereals the moisture stress during flowering is very detrimental. Usually, the moderate moisture stress does not affect the crop yield.

Mechanisms for overcoming moisture stress: Escaping Drought, Drought Resistance, Drought Avoidance and Drought Tolerance.

Plant Mechanisms to Conserve Moisture

Stomatal Mechanism

Drought resistant varieties closing stomata when drought prevails and opens the stomata during early morning and produces the photosynthesis rapidly with less amount of water.

Increased Photosynthetic Efficiency

In C_4 and CAM plants shows increased photosynthetic efficiency when compared to C_3 plants. CAM plants are highly drought resistant; C_4 plants are drought resistant when compared to C_3 plants. Lipid deposits on plant leaf surface will conserve more moisture. Crops like sorghum, soya bean are reducing the water loss by depositing lipids on plant surfaces under moisture stress conditions. In drought, plant shows reduction in leaf area results less transpiration and leaf expansion is limited. Parahelionastic movements: when plant leaves are oriented parallel to sun rays and thus by avoiding the load of solar radiation (legumes/ pulses).

Changes in Plant Morphological Characters

Leaves with thick cuticle, leaves with waxy surface, and leaves with spine would reduce drought and influence survival of the plants under moisture stress condition. Drought sometimes increases the water storage in plants (pineapple leaves). The plants with efficient root system, more root-shoot ratio, increase in lipid phase conductance on leaves, osmotic adjustments, drought tolerance of the crop varieties, mitigating drought high degree of tolerance, drought evaluation, plant developmental mechanisms, plant morphological adaptations, plant physiological adaptations, remobilization of reserves and breeding for drought resistance are very important in conserving the soil moisture in drought condition.

Tillage Practices: Zero tillage, minimum tillage, summer ploughing, blade harrowing and tractor drawn cultivators are used in dry land cropping.

The commonly used crops and varieties in dry land areas are sorghum, groundnut, pearl millet, red gram, sun flower, cotton with drought resistant varieties are chosen. The time of sowing usually based on onset of first monsoon rain. Irrigation is followed during the critical stages of the crop; efficient water harvesting methods are followed for water storage and to reuse the stored water through supplemental irrigation by efficient irrigation system.

Ameliorative Measures on Dry Land Crops

Anjum *et al.*, (2011) reported that the brassinolide application improves the drought tolerance in maize through modulation of enzymatic antioxidants and leaf gas exchange. Application of salicylic acid 0.7 ppm and glycine betaine at 100 ppm at flowering stage is reducing the adverse affects of drought stress in sunflower was reported by Ashraf (2010). Under drought stress condition, 2-aminoethanol per treatment increased the grain yield of barley by 25-30 % Application of propiconazole increased the enzymatic activities in cowpea (ascorbic acid, polyphenol oxidase, tocopherol etc.) helps to overcome drought. Application of triadimefon to sun flower increased enzymes like proline, glycine betaine catalase etc., reduces the drought stress. Application of paclobutrazol

minimizes the water stress in Groundnut Influence of extreme weather disasters on global crop production was extensively reported by Lesk *et al.*, (2016).

Improving Soil Moisture Storage in Dry Land Areas

Soil moisture lost as evaporation from the soil surfaces and as transpiration from the plant surfaces. Both are affecting crop productivity. The evapotranspiration losses can be produced by-

- Suitable selection of crops (drought resistant),
- Using different types of Mulches,
- Using different types of antitranspirants,
- Wind breaks and shelter belts,
- Effective methods of weed control.

Types of Mulches

- Soil mulch
- Stubble mulch
- Plastic mulch, and
- Vertical mulching.

Using of Antitranspirants

Nearly 90 percent of water absorbed by the plants is lost by transpiration. Antitranspirants are any material applied to transpiring plant surfaces for reducing water loss from the plant. There are four types: (1) stomatal closing type, (2) film forming type, (3) reflectant type, and (4) growth retardants type. **Stomatal closing type:** Most of the transpiration occurs through the stomata on the leaf surface. Some antitranspirants reduce water loss through stomatal closing is called stomatal closing type. E.g. fungicides like phenyl mercuric acetate (PMA), herbicides like Atrazine in low concentrations. **Film forming type:** Plastic and waxy materials which form a thin film on the leaf surface retard the escape of water due to formation of physical barrier. E.g. Hexadeconol, Silicon. **Reflectant type:** These are white materials which form a coating on the leaves and increase the leaf reflectance and reduce the transpiration. E.g. Kaolin, Celite. **Growth Retardants:** These chemicals reduce shoot growth and increase root growth and thus enable the plants to resist drought and they may induce stomatal closure E.g. Cycocel.

Conclusion

Wind breaks are any structures that obstruct wind flow and reduce wind speed. Shelter belts are rows of trees planted for protection of crops against wind. Due to reduction in wind speed, evaporation losses are reduced and more water available to the plants in drought areas. Effective weed control methods: Transpiration rate from weeds is more compared to crops. Effective weed control in dry land agriculture leads to increasing availability of soil moisture

to the crops. These are the most useful measures to reduce the transpiration losses in dry land areas. Commonly, watershed is any surface area from which rain fall is collected and drains through a common point. Watershed is synonymous to a drainage basin or catchment area. The size of the watershed varies from a few hectares to several thousands of hectares. Watersheds are classified into micro, mini and macro depends on size. Basically, watershed is as a component of biological, physical, economical and social system and meets the needs of the people and animals in sustained manner.

References

Anjum, S.A., Wang, L.C., Farooq, M., Hussain, M., Xue, L.

L., Zou, C.M., 2011. Brassinolide application improves the drought tolerance in maize through modulation of enzymatic antioxidants and leaf gas exchange. *J. Agron. Crop Sci.* 197, 177–185. Doi: 10.1111/j.1439-037X.2010.00459.x.

Ashraf, M., 2010. Inducing drought tolerance in plants: recent advances. *Biotechnol. Adv.*, 28, 169–183. Doi: 10.1016/j.biotechadv.2009.11.005.

Lesk, C., Rowhani, P., Ramankutty, N., 2016. Influence of extreme weather disasters on global crop production. *Nature*, 529, 84–87. Doi: 10.1038/nature16467.