Growing Crops on North-South Slopes

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Background

Agricultural producers in arid regions have always dealt with the uncertainty of weather and its effect on crops. Climate change has brought increased temperatures and variability in precipitation. In the future, crop production in arid regions will be even more precarious.

In arid regions that rely solely on precipitation for crop production, several techniques have been developed to make the most use of available water (Unger et al., 2006). Sowing before or at the beginning of the wet season is most important. Water can be conserved by increasing the spacing between plants through reduced seeding rate and/or increased row spacing. Mulching during the off-season reduces water use and this is typically accomplished by lightly tilling the surface soil to create a “dry mulch” which also disrupts upward capillary movement of water. Summer fallow systems where crops are grown in alternative years is a way to build up soil water content. Crop varieties have been developed which are adapted to arid regions.

Landscape contouring

Contouring the landscape into N-S slopes is a novel approach to growing crops in arid regions. Crops grown on the north-facing slope receive less solar radiation and have the potential for increased yield compared to crops grown on flat ground. In natural ecosystems in arid regions, the north-facing slope has more plant growth than the south-facing slope. Solar radiation provides the energy required for evaporation of water from the soil and transpiration of water from the plant. Water will be conserved on the north-facing slopes of artificially contoured land, and the expectation is that crop yield will be concomitantly increased. Perhaps of most importance is the reduction in evaporation of water from the soil surface on the north-facing slope which would allow for more water to be used in transpiration which is directly related to crop growth. Conservation of water in dryland systems is critical and decreases the chance of crop failure due to running out of water before maturity.

Site selection

Soils for contouring the landscape must be chosen carefully. In order to minimize carbon emissions, soils with high organic matter content in the surface should be avoided. The most likely candidate would be deep alluvial soils with uniform texture and minimal horizon development, which would be in the soil order of Entisols. Aridisols have slightly more horizon development than Entisols, and may also be a candidate soil order. Regardless, at least 1 m of suitable surface soil is required for growing most field crops (FAO, 1998). The contouring should not expose subsoil unsuitable for crop growth. Also, care should be taken not to bring up salts into the surface soil where the crops are to be grown. Many soils in arid regions contain a petrocalcic layer (commonly called caliche) which is a cemented hardpan from accumulation of carbonate of calcium and other cations. Surface contouring, especially if accompanied by deep ripping, may break thin petrocalcic layers and improve the soil, but exposure of thick petrocalcic layers would be deleterious to crop growth.

Crop selection

Many options are available for crops to be grown, but crops grown locally will be given priority. The assumption is that this project will be conducted in a region with a Mediterranean climate. In this case, wheat will be chosen along with barley both of which can be grown for grain or forage. Forages such as alfalfa and berseem clover may be considered. The increased exposure of the south-facing slope to solar radiation could be used to grow a warm season crop such as melons in the frost-free portion of the cool season (Tucker, 2016), although this crop will probably require supplemental irrigation. Other warm season crops such as sorghums or millets could be grown on either slope but will required irrigation in areas without summer rainfall. At least two cultivars of each crop should be grown, differing in an important characteristic such as drought tolerance or maturity.

South-facing slopes

The utility of the north-facing slopes for conserving water and improving crop growth in an arid environment is obvious, but how to use the south-facing slopes if at all is open to several possibilities. One option is to do nothing at with the south-facing slopes including not planting a crop of any kind. Sowing the south-facing slope with a warm season crop during the cool season as mentioned above is worth considering. The south-facing slope could be covered with plastic to protect the soil and avoid erosion. A system to collect rainwater falling on the south-facing slope could be installed. This rainwater could be collected and placed in a holding pond for irrigation of other crops on the farm or to provide supplementary irrigation water for the north-facing slope. Finally, the idea of cropping the south-facing slopes could be abandoned and solar panels installed instead.

Treatments

The treatments will include angle of the slopes, crop species, and cultivars within crop species. Treatments will be replicated 2-4 times in order to be able to calculate measurement error and draw statistical inferences. The angle of the slopes will be either steep or shallow and include flat terrain as a control.   The length of the slopes will be constant (10-15 m) and the height of the slopes will vary depending on the angle of the slopes. The crop species will be determined by what is grown locally, but could include wheat, barley, a cool season leguminous forage, a warm season crop such as melons, and a warm season grain or forage such as millet or sorghum. Two cultivars of each species will be chosen which differ in drought resistance or other characteristics pertinent to the objectives of this project.

Measurements

The growth of the crops will be monitored using imagery from sensors on satellites, drones, tractors, and/or hand-held devices. Vegetation indices such as NDVI will be calculated from this imagery and used to estimate treatment effect on growth. It may be necessary to ground-truth the growth predicted from the imagery with hand sampling of the crop at regular intervals. Yield will be measured at harvest time along with some determination of quality appropriate for the particular crop.

Evaluation

The differences among treatments will be evaluated using statistical tests of significance. The efficiency of water use between flat and contoured terrain will be compared. The overall benefit of contouring will be evaluated in terms of cost vs returns from crop yield. Greenhouse gas emissions from the contoured landscape will be estimated.

References

Unger, P.W., Payne, W.A. and Peterson, G.A. 2006. Water Conservation and Efficient Use. In Dryland Agriculture (eds. G.A. Peterson, P.W. Unger and W.A. Payne). https://doi.org/10.2134/agronmonogr23.2ed.c3

FAO. 1998. Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56. https://www.fao.org/3/x0490e/x0490e0e.htm#readily%20available%20water%20%28raw%29

Tucker, P. 2016. Legend Produce Cantaloupe Yuma Bed. https://www.youtube.com/watch?v=UA1PUXioAdw

Biography

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Dr. Michael Ottman is a retired Cooperative Extension Specialist for Agronomy and emeritus faculty member at the University of Arizona School of Plant Sciences. His research interests include the effects of fertilization and irrigation on crop yield, how climate change will affect crop production in the future, use of proximal sensing for crop management decisions, and modeling crop growth and development. His Cooperative Extension program uses research based information to improve the efficiency of crop production, particularly in the use of resources such as fertilizer and water. His work has focused on the irrigated production system of Arizona which is similar to the agricultural systems used in arid regions throughout the world. His research on fertilizer has focused primarily on nitrogen and phosphorus application to wheat, barley, sorghum, and alfalfa. He has worked on irrigation management, but in particular he has investigated sub-optimal irrigation strategies for alfalfa and barley in an effort to conserve water. He has written many publications for agricultural practitioners that are available from the University of Arizona College of Agriculture and Life Sciences (https://extension.arizona.edu/pubs). His research has been published primarily in peer-reviewed crop science journals such as Agronomy Journal and Field Crops Research but, as a co-author, he has also published in journals related to climate change, plant biology, and engineering. More information about Michael Ottman can be found at https://profiles.arizona.edu/person/mottman and https://cals.arizona.edu/spls/content/michael-0.