Supplemental Irrigation for Improved Dryland Agriculture with Climate Change
気候変動に適応する乾燥地農業の改善のための補給灌漑

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1. Introduction

Dry environments are experiencing severe and growing water scarcity. There is limited potential to substantially increase water resources in dry areas. Furthermore global circulation models predict that precipitation, and hence water resources, in dry areas will decline as a result of climate change in the coming decades. Where water is more limiting than land, the focus must shift from land productivity to water productivity. However, this will require major changes in the way water is managed in agricultural. Water productivity can be increased by improving crop water management and practices, such as supplemental irrigation (SI).

In rainfed agricultural systems crops productivity and stability depends largely on the rainfall amounts and annual fluctuations and on seasonal distribution. None of those characteristics is optimal in most of the time. That is why farmers in the rainfed systems suffer from low productivity and instable incomes especially in arid and semiarid regions. Supplemental irrigation is a practice designed to overcome this problem by applying little water to the rainfed crops only when rainfall fails to provide sufficient moisture for normal plant growth. SI practices have also a role in the adaptation to climate change.

2. Results

2.1 Increasing yield and water use efficiency

Recent research outputs has shown that supplemental irrigation is not only useful for alleviating soil water stress during drought spells but also to modify crop calendar so crops can benefit more from rainfall and can avoid harsh climatic condition. The first autumn rainfall in a Mediterranean climate determines the starting of the growing season of field crops like wheat. Often rainfall comes late and plants inter the cool winter months in early growing stage. Due to that winter crops cannot benefit fully from soil water at later stages especially that winter frost may affect the crop at early stage. Supplemental irrigation is used to overcome this problem by applying little water to plant the crop early in the season without rain. When rain comes late the crop is well developed and can benefit from climatic conditions and cultural practices. Drought spells occur later in the spring during flowering and grain filling and full and deficit SI can reduce the stress and improve both yield and water productivity. Early planting of wheat in Syria with 50 mm of SI has increased wheat yield on average by over 1.0 t/ha with water productivity increased by 50%. Deficit and full SI later in the spring resulted in further increase in yield and water productivity of 3.3 t/ha and 2.2kg/m^3 respectively (Oweis et al., 2006). In Karkheh river basin in

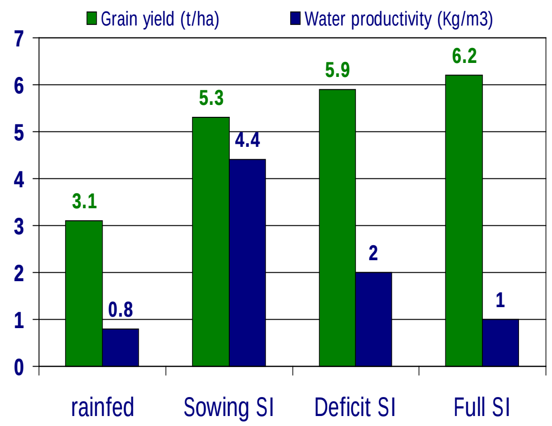

Figure 1. Impact of supplemental irrigation on wheat yield and water productivity in Ankara, Turkey (Ilbeyi et al., 2006)
トルコ・アンカラにおける SI がコムギ収量と水生産性に与える影響

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Iran early planting of wheat and barley with one dose of SI increased wheat yield from 2.4 to 3.8 t/ha and barley from 2.2 to 3.4 t/ha with corresponding water productivities of about 2.53 kg/m^3 (Tavakoli et al. 2012). In the Anatolia of Turkey early planting with SI increased wheat yield from 3.1 to 5.3 t/ha with highest water productivity increase of 3.6 kg / m^3. Further deficit and full SI in the spring increased yield by 0.6 and 0.9 t/ha respectively (Figure 1).

2.2 Adaptation to Climate change

Climate change affects all ecosystems but especially rainfed areas as they are more sensitive to drought spells. The potential impacts of climate change on dryland agriculture are very complex and vary from one region to another. Main changes include lower rainfall amounts, increased variability and extreme events such as drought (IPCC 2014). Generally rainfed systems will be directly affected by climate change by increasing evapotranspiration and reducing soil water which will put more stress on all plants, shortening crop growing periods and reducing yields.

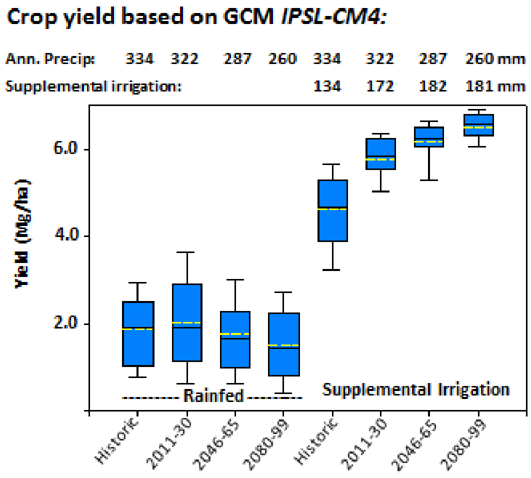

Figure 2. Climate change alleviation potential with supplemental irrigation of wheat in Aleppo, Syria (Sommer et al., 2011)
シリア・アレッポにおける SI によるコムギの気候変動緩和ポテンシャル

Research has shown that SI can alleviate the impacts of climate change on crops by reducing the drought impact and by compensating for reduced rainfall amounts. The case of wheat in Syria has shown that SI not only eliminates the diverse effects of climate change but also allows the crop to benefit from the positive impact of increased CO_2 with availability of more water (Sommer et al., 2011) (Figure 2).

3. Conclusion

The benefits of SI go beyond yield increases to support plant growth during dry spells in the spring also to maximize water productivity. Climate change negative impacts can be reversed in rainfed systems by applying SI. It is recommended that when water resources are limited, highly efficient and productive options like SI are adopted and that policies create the enabling environments for that.

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＜和文要約＞乾燥環境下において水不足の問題は深刻であり，数十年先には気候変動の結果として降水量，水資源量が減少すると考えられている。水が土地よりも制限要因となる地域では，土地生産性よりも水生産性の向上へと考えをシフトするべきである。Supplemental Irrigation（補給灌漑）はその解決策の一つである。本報では，イラン，トルコ，シリアでの補給灌漑の効果を検証する栽培実験の事例を紹介し，補給灌漑が干ばつ時における土壌水分ストレスの軽減としてだけでなく，栽培暦の修正にも有用であることを解説する。水資源が制限要因である状況下において，補給灌漑のような適応策やそれを実現化できる環境を整える政策が望まれる。