

## **NM WRRRI Student Water Research Grant Final Report**

**Student: Paramveer Singh**

**Advisor: Dr. Sangu Angadi**

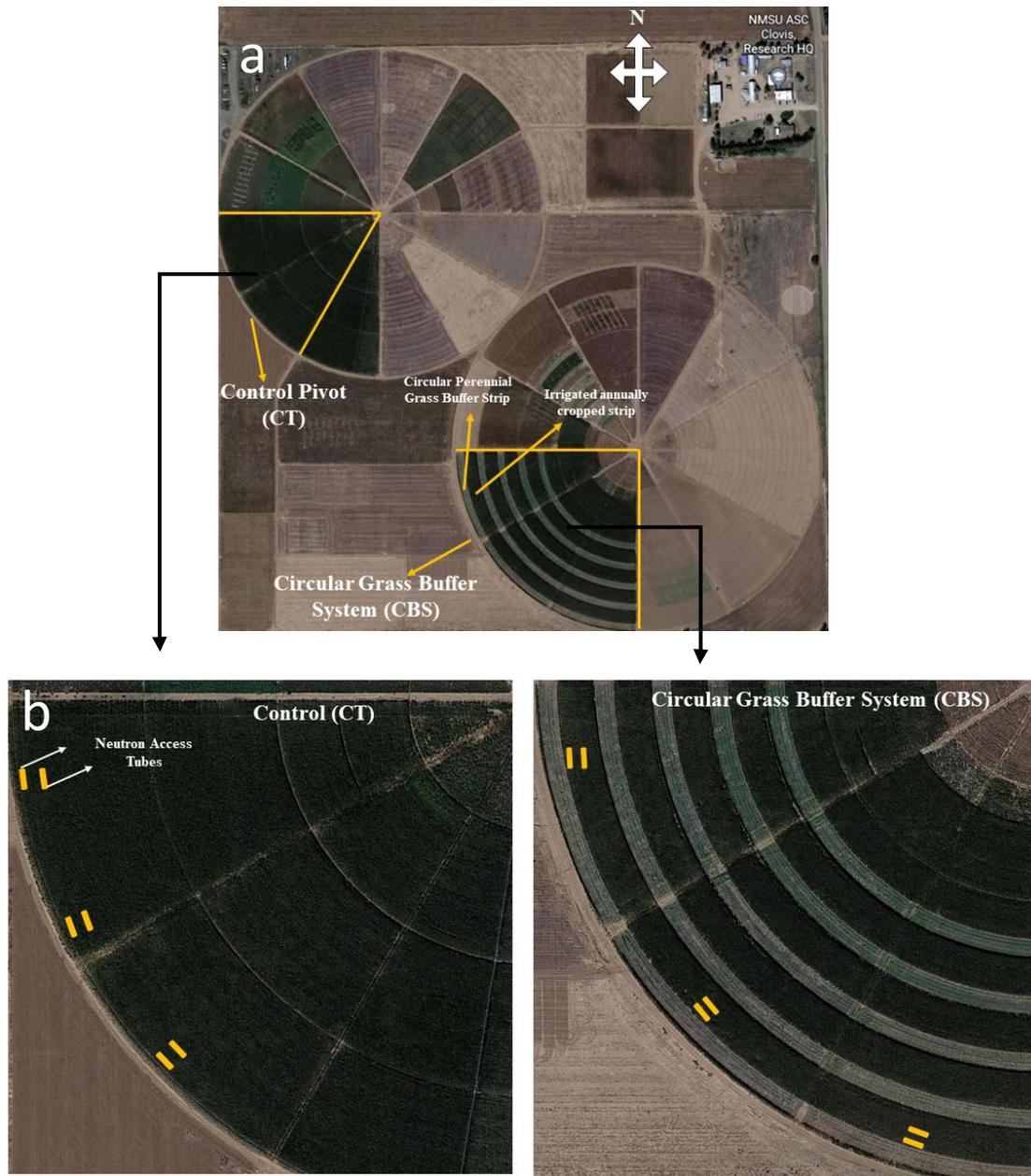
**Project: Improving Green Water Use Proportion in a Center Pivot Irrigation System by Using Circular Grass Buffer Strips**

### **Introduction**

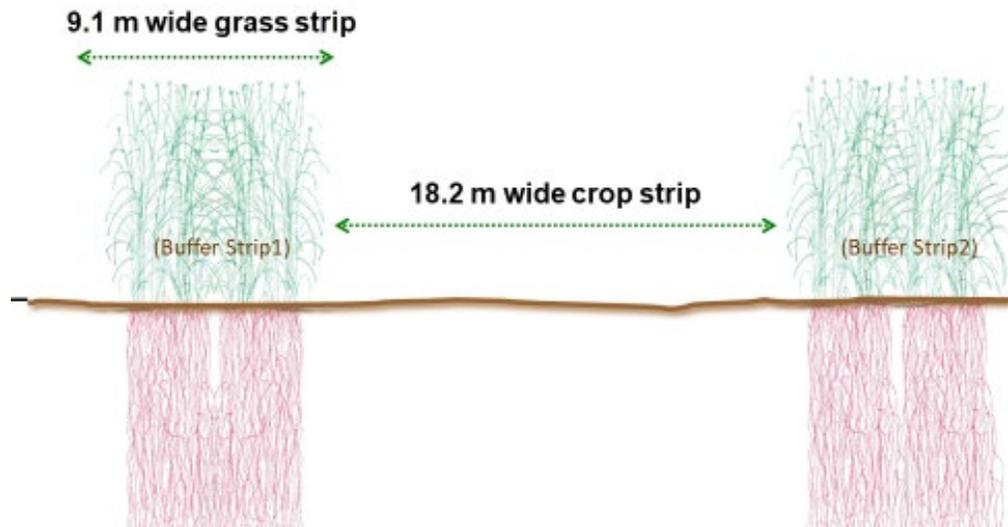
Water security is the monumental challenge for semi-arid Southern High Plains (SHP) of the USA. Dwindling ground water reserves of the Ogallala Aquifer (OA) threatens agricultural production, economy, and rural livelihoods in eastern New Mexico. An increase in conservation and efficient use of intense rains by irrigated agriculture in the region will help ease the pressure on OA by allowing farmers to reduce irrigation inputs without affecting crop growth and yield. A simple, elegant and cost-effective strategy was developed by Dr. Angadi, which involves rearranging the dryland portion of partial pivots into circular buffer strips of native perennial grasses (CBS) alternating with crop strips. This system is expected to offer several benefits, including improved efficiency of the water cycle. With the CBS acting as multiple barriers, there may be a reduction in surface runoff and wind speed within the crop strip. The CBS provides year around ground cover to increase infiltration of rainwater and reduce runoff and evaporation.

### **Materials and Methods**

The experimental trial consists of the southwest quarters of two side by side pivot circles at ASC, Clovis NM (Figure 1a). One serving as a CONTROL (CT) and other as CBS. Five circular buffer strips of perennial grasses of 9.1 m width were planted on June 2016 at the southwest quarter of a center pivot at NMSU ASC, Clovis NM (Figure 1a and 2). The grass buffer strips were arranged alternately with 18.2 m wide crop strips. Corn, being the most dominant water-intensive crop grown in the region, has been selected for this study. Pioneer P1138 AML cultivar of corn was planted in both quarters on 05/02/2020 with 0.76 m row spacing. Each crop strip in CBS had 24 corn rows. A total of 390 mm of irrigation was applied to corn in CBS and control. Grass strips of CBS did not receive any irrigation this year. As the corn grew above grass height (benefit of CBS is minimum on corn), grass was swathed on 16<sup>th</sup> July 2020.



**Figure 1. a)** Experimental site includes section of two nearby center pivots (outlined by yellow lines) at New Mexico State University Agricultural Science Center, Clovis NM. One pivot served as treatment pivot at which 5 circular perennial grass strips of 9.1 m width arranged alternately with irrigated crop strips of 18.2 m were established in 2016 summer, and the other pivot served as Control (CT). **b)** Location of neutron access tubes with 2 tubes per replication at CT and CBS pivot respectively.



**Figure 2.** Arrangement of grass and crop strips in circular grass buffer system (Left). Location of CT (control pivot without circular grass strips) and CBS (with circular grass buffer strips) at NMSU ASC, Clovis NM.

To assess the potential improvement of the water cycle by circular grass buffer strips, the soil profile moisture (using Neutron Gauge), leaf water potential of corn, and biomass production observations were made around a large rainfall event of 44 mm in the 2020 growing season. First set of tubes were installed 1.5 m from grass strips in CBS and from the outer edge of the pivot in CT pivots. This distance would be referred to D1 in the text. A second set of 3 tubes were installed at 18.2 m from outer edge of both CBS and CT pivot which is referred to as D2 in the text. Within CBS, D2 is in the middle of the crop strip and at farthest distance away from the grass buffer strips which allowed us to test if there was spatial aspect of latter mentioned benefit of CBS. Similarly, D2 in CT is at the distance



**Figure 3.** Installation of neutron access tubes in the study area.

where the border effect on the crop growth diminishes and can differ in rainwater storage as compared to D1. Thus, placement of D1 and D2 in both systems allowed us to have better picture of rainwater storage in the outermost 18.2 m (24 maize rows) maize crop with or without buffer effect. The season was extremely dry, and the 44 mm rainfall event that occurred over two days (07/04/2020 and 07/05/2020), was the only suitable event for such assessment. Soil moisture readings with the Neutron gauge taken on 06/30/2020 (before rainfall) were subtracted from the readings of 07/07/2020 (36 hrs. after rainfall) to arrive at rainwater storage. Another set of Neutron gauge readings were taken on 07/11/2020 (4 days after rainfall) to arrive at soil water extraction. Leaf water potential was measured on 07/10/2020 to compare plant water status. Biomass weights on 06/30/2020 (3 days before rainfall) and 07/11/2020 (4 days after rainfall) were subtracted to arrive at biomass increase (BMI). Water use efficiency (WUE) of this short growth period around rainfall was calculated by dividing BMI with rainfall amount received (RF) and soil water change ( $\Delta S$ ) over 10-day period around the rain event. WUE was calculated using following equation:

$$WUE = BMI / (RF + \Delta S)$$

## **Results and Discussion**

Soil profile measurements just before and immediately after the rain event indicated that CBS improved capturing and retainment of heavy rainfall at both D1 and D2 (Figure 4). Overall, there was a 21 mm increase in soil water in CBS as compared to 11 mm in CT after the rainfall. Of total amount of rainwater captured, 30% got stored at deeper depths (0.90 to 1.3 m) in CBS whereas in CT this proportion negligible. Improving water availability by trapping snow and rainfall runoff is an important benefit of shelter belts (Bird et al., 1992). Deep roots of grasses increase soil permeability and porosity, which increases infiltration and water retention (O'Hare et al., 2016). Perennial grass strips are denser, and offer resistance to the runoff better than woody or shrubby barriers (Dosskey et al., 2010). Thus, perennial grass strips might be causing ponding of rainwater in cropping area (crop strips) by blocking surface runoff and deep roots of grasses will aid in infiltration of high intense rain.

Over next four days, corn in both CBS and CT extracted almost all the soil water that got stored in the soil profile after rainfall. (Figure 4). In CBS, corn extracted 19 mm of water whereas in CT only 10 mm of water was extracted 4 days after the rain. Amount of water available in the soil profile is a key factor influencing water uptake by plants. Prior to rainfall, SWC of the soil profile ranged from 0.20 to 0.25  $\text{cm}^{-3} \text{ cm}^{-3}$  across various soil depths up to 1.3 m. Permanent wilting point at which plants cannot extract the water of the Olton Clay loam ranges between 0.23 to 0.25  $\text{cm}^{-3} \text{ cm}^{-3}$  (USDA NRCS,). This indicates that there was not much soil water available for maize to extract before the rainfall. As a result, soil water extraction amount and pattern after the rainfall followed a similar trend as observed in rainwater storage at both distances (Figure 4).

Leaf water potential (LWP) has been rigorously used to evaluate plant water status and stress index (Jones, 2004). Overall, CBS had 13% higher LWP than CT (Table 1). This effect of CBS reduced with increase in distance from the grass strip border. Slightly higher water extraction and lower stress levels resulted in 41% more biomass accumulation in CBS as compared to CT (Table 1). Biomass water use efficiency (WUE) of maize was significantly different between two systems in both years. In CBS, maize had WUE 31  $\text{kg ha}^{-1} \text{ mm}^{-1}$  which was 63% higher than CT. Rainfall was the main source of water and contributed most to evapotranspiration needs of the crop during this short 10-period. Presence of grass buffer strip increased storage of intense rainfall in the soil profile. Comparatively more amount of water available during high water demanding growth phase in CBS mitigated water stress levels and enhanced biomass accumulation (Table 1). As a result, more biomass was produced in CBS compared to CT which drastically improved WUE. With ground water reserves of OA shrinking, and climate change increasing crop water demands, increasing capture and use of rainwater may allow farmers to reduce irrigation inputs and sustain OA and irrigated agricultural production in the region.

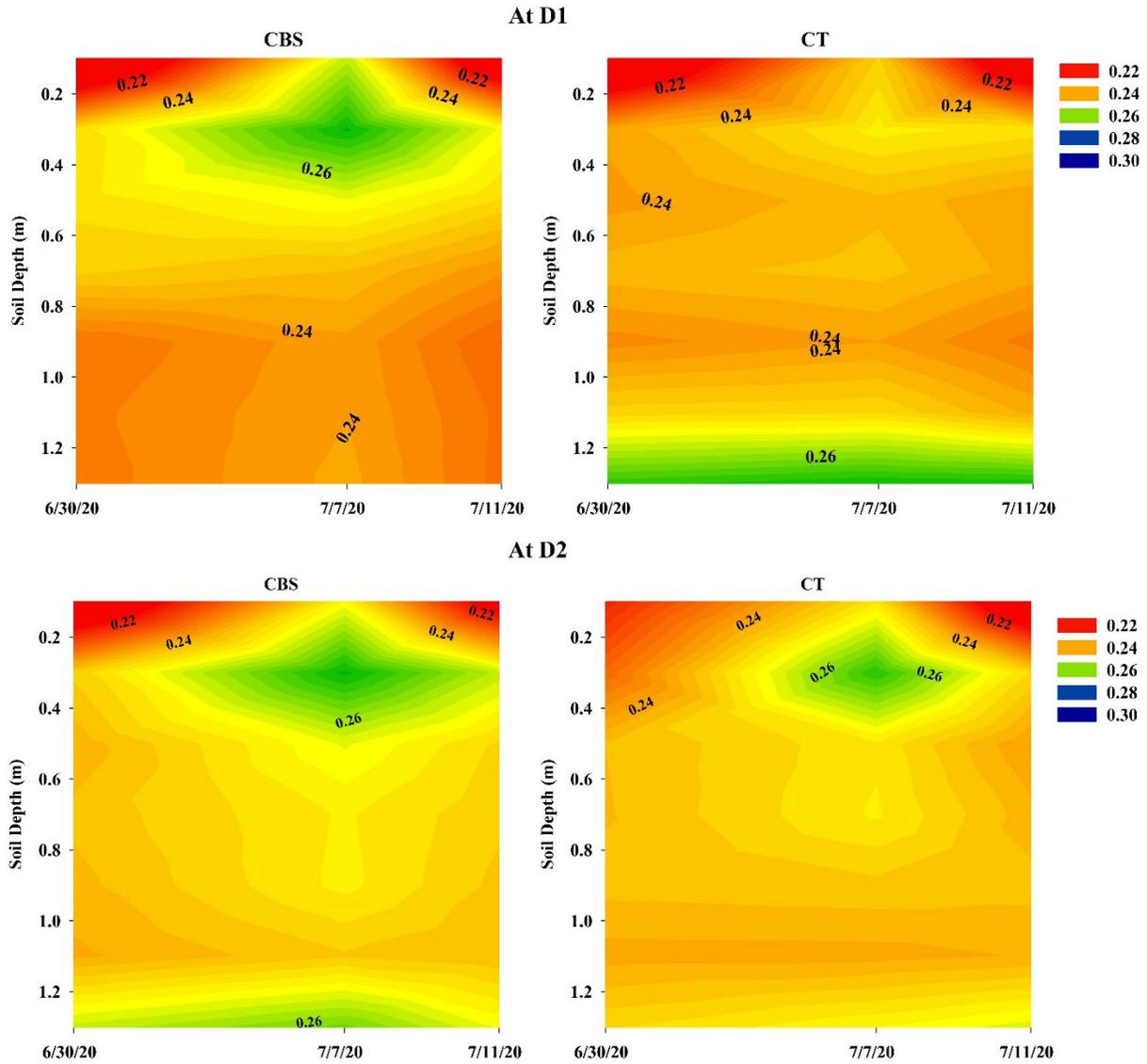


Figure 4. Change in soil moisture (indicated by the legend) across 7 soil depths (from 0.1 m to 1.3m) at two distances (D1 and D2) in first maize strip of CBS and CT pivot before the rain on 06/30/2020, 36 hours after a rain event of 42 mm on 07/04 and 07/05/2020, and 4 days after on 07/11/2020. CBS: maize with circular grass buffer strip; CT: no circular grass buffer strip.

**Table 1.** Amount of rainwater got stored up to 1.3 m of soil depth after two rain events (Storage), water use (ET), and water use efficiency (WUE) around the one rain event 2020 season.

	<b>BMInc (Kg ha<sup>-1</sup>)</b>	<b>LWP (-Bar)</b>	<b>WUE (Kg ha<sup>-1</sup> mm<sup>-1</sup>)</b>
<b>Treatment (T)</b>			
CBS	1230 a <sup>†</sup>	-13.5 a <sup>†</sup>	31 a <sup>†</sup>
CT	874 b	-15.4 b	19 b
<b>Distance (D)</b>			
D1	832 b <sup>†</sup>	-1.6 b <sup>†</sup>	19 b <sup>†</sup>
D2	1272 a	-1.3 a	31 a
<b>T*D</b>	-	-	-

<sup>†</sup> Different alphabets for treatment and distance values represents significant difference at  $p \leq 0.05$ .

<sup>††</sup> Different alphabets for treatment and distance values represents significant difference at  $p \leq 0.10$ .

\*\* Represents significant interaction between treatment and distance levels at  $p \leq 0.05$ .

CBS: maize with circular grass buffer strip; CT: no circular grass buffer strip

D1: at 1.5 m distance from the inner edge of perennial grass buffer strip in CBS and outer edge of the CT pivot

D2: at 16.2 m away from the outer edge in CBS and CT pivot, respectively.

## **Beneficiaries**

Results indicate that CBS improved conservation and use of rainwater by irrigated agriculture. This will encourage farmers to reduce irrigation inputs as additional water from rain will mitigate the impact of water stress on crop growth and yield. Thus, CBS may prove instrumental by sustaining OA, which will benefit the whole region.

## **Work done in 2021**

Plant and soil samples were collected for isotope analysis. But due to continued closure of the ARS USDA lab in Lubbock because of the Covid-19 pandemic, and loss technical staff member, we were not able to do isotope analysis of plant and soil water to assess proportion of green water use by crops. Plant and soil samples are kept in the cold storage. We are planning to carry out the analysis once the lab opens up and hires required staff.

## **Budget**

Due to Covid-19 pandemic, work in summer 2020 suffered and a no-cost extension was provided till October 2021. Annual ASA-CSSA-SSA meeting in 2020 was held virtual. Again in 2021, USDA-ARS lab in Lubbock was closed. So, the money allotted for these two travels were used to pay for summer salary in 2021 where again we collected soil and plant samples. The total budget was used to cover for summer salary in 2020 and 2021 and getting supplies.

## **Presentations and Conferences**

**Singh, P.**, Angadi, S., Begna, S., Dubois, D. W., Ghimire, R., Idowu, O. J., 2020 65<sup>th</sup> Annual New Mexico Water Conference (Virtual), "Improving Green Water Use Proportion of Irrigated Agriculture By Circular Buffer Strips of Perennial Grasses", Scope: International. (October 27, 2020).

**Singh, P.**, Angadi, S., Begna, S., Dubois, D. W., Ghimire, R., Idowu, O. J., 2020 ASA-CSSA-SSSA International Annual Meeting, ASA-CSSA-SSSA Societies, Phoenix AZ (Became Virtual), "Improving Green Water Use Proportion of Irrigated Agriculture By Circular Buffer Strips of Perennial Grasses", Scope: International. (November 12, 2020).

**Singh, P.**, Angadi, S., Dubois, D., Idowu, O.J., Ghimire, R., and Begna, S., 2021 Western Society of Crop Science Annual Meeting, Virtual, "Simple Design of Circular Grass Buffer

Strips Improves Green Water Use Proportion in a Center Pivot Irrigation Systems”, Scope: International. (June 22, 2021).

**Singh, P.**, Angadi, S., Dubois, D., Idowu, O.J., Ghimire, R., and Begna, S., 2021 Soil and Water Conservation Society Annual Meeting, Virtual, “Native Perennial Grasses as Circular Buffer Strips Improves Green Water Use Proportion in a Center Irrigation System”, Scope: International. (July 26, 2021) **(1st Prize)**.

### **Degree completion**

The plan is to finish PhD by fall 2022 and then look for a research job.

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