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Assessment of sesame crop (*Sesamum indicum* L.) in reference to various techniques

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ABSTRACT

Aim: The aim of this study was to assess the performance of sesame crop (Plant Height , Moisture Content , No Capsule/ plant, Seed weight , and Mean Yield)under three water harvesting techniques(tied furrows, semi-circular bund and contour basin "traditional terraces") assigned to the main plots, and three watering practices (fully-irrigated, supplemental irrigation and rain fed systems) assigned to sub-plot.

Materials and Methods: Water was applied from a farm reservoir "Hafir" to the field by a mobile gun sprinkler. Data on plant height (cm), number of capsules per plant, seed weight (mg), and seed yield (kg/ha) were recorded.

Results: Analysis of variance indicated that both water harvesting techniques and watering application practices significantly ($p<0.05$) improved sesame growth attributes and grain yield. The mean seed yield obtained from supplemental irrigated treatments (467.5 Kg/ha) is significantly higher by 29% than yield obtained with rain fed system (361.3 Kg/ha) and equivalent to 72% of that obtained with full irrigation (644.3 Kg/ha).

Conclusion: It was concluded that application of supplementary irrigation in congestion with semi-circular bund could be an important climate change adaptation strategy in areas with variable rain amount and bad distribution.

Keywords: Sesame, water harvesting systems, supplementary irrigation, rain fed.

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Introduction

Sesame (*Sesamum indicum* L.) is a tropical and subtropical crop widely grown in Sudan, for itsedible oil and other industrial products, and it is cultivated in Sudan under rain-fed conditions, in North Kordofan, Gadaref, Damazine, Sinnar, Kassala and Renk (Loggale, 2018). The crop production in these areas fluctuates from one year to another due spatial and temporal variability of rain fall. Thus, drought coupled with climate change pose a potential problem to sesame production under rain-fed conditions in Sudan which necessitate adoption. Of some mitigation and adaptation measures. To alleviate the problems associated with drought, and low rain fed productivity has spurred interest in growing sesame under irrigation (Ahmed, 1998) or supplemental irrigation (Loggale, 2018) in limited areas.

Consequently, to achieve our goal of improving sesame production it is necessary to resolve its water constraint by adopting a suitable water harvesting technique. Traditionally people in Butana rain fed area use in situ water harvesting technique of "truss" cultivation. Other recommended options are to employ micro catchments techniques of detention basins or tied furrows, A review of early work on sesame reported by Loggale (2018) emphasizes the importance of supplemental irrigation of sesame in Abu Naama. Other investigations revealed that at least a single irrigation in the season for rain fed crops was necessary to give a reasonable economic yield (Salih et al, 2003). Loggale (2018) reported that Mahasin et al. (1988) concluded from their study on sesame in Gezira Research Station that maximum of four irrigation regimes are needed to obtain a decent crop. This open the question of what is the optimum number of needed supplemental irrigation of sesame crop, when to apply it and how much water to apply. To achieve such target the labour intensive system of monitoring soil moisture may be used. A better alternative is to develop a mathematical model for scheduling supplemental irrigation.

For the design of water harvesting system structure to ensure a successful production two alternative rationale were usually used: one is to collect rain fall in receiving area to supplement water deficit in specified cultivated area (micro catchment systems receiving direct rain fall such as semi-circular pond with water storage in the soil). In such system the driving force is to cultivate specified area. The other alternative is the determination of the area that fully utilizes the available runoff and use the resulting area as storage and cultivation area. The runoff discharge is either fully occupied in a series of detention basins or the discharge is flowing continuously and occupied in an area shaped by open end ridges or the discharge is spreading in a flat area and spill over traces that act as spillways to assure a specified design water application depth. This calls for running a series of experiments for a more in-depth understanding of response of these two water harvesting rationale to supplemental irrigation. In addition the suitable system to apply water to the area (either surface spreading or gun sprinkler) in each rationale need to be determined.

Materials and Methods

Study site, location and characteristics:

The experiment was conducted on growing seasons at El Gadambalyia village (113001 ha) in Butana rain fed area (latitudes 13°45′ and 14 ° 15′ N and longitudes 34° 45′ and 35°).This is the oldest rain fed mechanized and subsistence farming schemes in the Butana region. The area is semi-arid (van der kevie 1973), with annual rainfall ranges between 400 to 500 mm (June to September). The annual mean temperature is (40 °C in summer to 16 °C in winter), with erratic rainfall (350 to 550 mm/annum). The average annual rainfall is less than 44 percent of the potential evapotranspiration. The monthly potential evapotranspiration varies from a minimum of 130 mm in August to a maximum of 205 mm in May with a total average of 1033mm per year (Ahmed, 2009). Temperature is high (mean daily maximum temperature is over 40° C in April and drops to about 17° C in January). Relative humidity at mid day varies from 5 to 9 % in March to 57% in August. There is a large pit farm reservoir 400 m3 which last, when full at least to the end of the time of harvesting.

Treatments and Experimental Design:

A randomized factorial design with three replications is used. Three watering application systems (fully- irrigated, supplemental irrigation and rain fed system) are assigned to sub-plot, while three water harvesting techniques (tied furrows, semi-circular bund and continuous contour basin "traditional terraces") are assigned to the main plots. Tied furrows were constructed, by machine using a ridger and ties are made manually, with over flow cross-ties 1.5 m apart, 0.30 m height, and 0.3 m at the base, thus creating mini-basin. The dimensions of the semi-circular bund are height : 0.2 to 0.5 m, base width : 0.70 m, side slopes : 3 : 1, crest width : 0.1 - 0.25 m, and diameter : 12 m - 40 m, while dimensions of contour basin "terraces" are:Height : 0.2 - 0.4 m, Base width : 0.8 m, Side slopes : 1 : 1.5, Crest width : = 0.2 m, Length of perpendicular basin : 2 - 3 m, Spacing of perpendicular basin : 2 - 5 m, and Spacing : 20 m, (Critchley and Siegert ,1991). A spacing distance of 1.5m was kept between plots between and 1.0 m between sub-plots. The irrigation water is introduced to the watering application systems from constructed reservoir (Hafirs) via a water pump with sprinkler gun carried as one unit with a one wheel hand move cart. For land preparation the field was plowed with disc harrow, leveled, topographically surveyed, divided, and shaped according to specifications of each one of the intended water harvesting technique. Following Ahmed, (2009) and Loggale (2018) Khidir sesame variety was sown manually at spacing of15 cm apart on 2nd of July 2019 and 2020, and other cultural practices (seed rate, weeding, fertilizer, rain watering) are adopted as recommended by Agricultural Research Corporation (ARC) and they are kept the same for all treatments(Ahmed, 1998).

Data Collection and Analysis: Each data collected is replicated three times and it includes: 1- crop data (days to crop growth stages, yield components "number of branches per plant, number of capsules per plant, number of seeds per capsule and plant height" and, Yield "number of seeds per capsule, thousand seed weight, and seed yield in Kg/ha"), and 2- Soil moisture data using gravimetric oven dry method (Auger replicated soil samples were taken at soil depth interval of 0.20 m to 0.6 m at two soil depth every two weeks. Collected data was analyzed by descriptive statistics (Statistic 10 software) for determining the mean, standard deviation, coefficient of variation, analysis of variance using the least significant difference at 5% and, mean separation using least significance difference (LSD) (Duncan,).

In reference to Farbrother (1977) Ahmed et al (2010) and Loggale (2018) the supplemental irrigation water was applied when 93 mm of soil moisture is depleted The soil moisture is monitored regularly every three days and occasionally determined when the soil is observed to start to dry or cracks is seen. Soil moisture is determined by oven dry gravitational method at 0.20 m to one meter depth. In the two seasons, the provision of supplementary irrigation water was made in the period of pod setting. Two supplemental irrigations were given in the first season (2021), while three supplemental irrigations were made during the second season (2021). For full irrigation treatment watering is scheduled and determined by CROPWAT program in reference to crop stage root depth, bulk density, reference evapotranspiration, crop factor (according to Penman-Monteith equation -Allen et al,, 1998), and effective rain fall (measured by automatic rain gauge at the site-Fao.org program). Both surface run off and deep drainage were neglected because the area was flat and the heavy clay soils restrict the movement of the water to deeper layers. Hence the change in soil water storage between two successive samples was taken as the amount of water used by the crop during that period (Ahmed et al., 2010).

Results and Discussion

The performance of sesame crop studied with watering systems and harvesting techniques. In general, there is significant improvement in all growth attributes and seed grain yield by adopting supplemental irrigation over rain fed watering system. In particular, the mean seed yield obtained from supplemental irrigated treatments (467.5 Kg/ha) was significantly higher by 29% than yield obtained with rain fed system (361.3 Kg/ha), and equivalent to 72% of that obtained with full irrigation (644.3 Kg/ha). This results were in line with Loggale (2018) who reported that " there were statistically significant differences (p=0.01) between moisture regimes and plant height, number of capsules per plant, and seed yield, and the highest seed yield (832 Kg/ha) was obtained from fully-irrigated treatment in the clay soil at Abu Naama- Sudan. When comparing water harvesting techniques Semi-circular bund showed significant increase in mean grain yield, and moisture content while tied furrows showed significant increase in seed weight and plant height. The traditional Basin (terraces) resulted in the least values of yield and yield attributes except it was only highest for number of seed per capsule. These results were corroborated with Asif et al (2015) who investigated the growth and yield attributes of sesame was significantly ($P < 0.05$) affected by all the levels of field planting geometry and amount of irrigation regimes. These results is in agreement with Hailu et al (2018) who indicated that Sesame yield response to water harvesting techniques of alternate furrow, fixed furrow, and conventional furrow in Ethiopia resulted in highest mean yield was obtained from conventional furrow treatment s with highest and lowest water amounts. Hailu et al (2018) attributed the superiority of the ridge-furrow rainwater harvesting technique to its overflow capacity to protect the crop from high flood water and its capability to store water within the furrows and lessen the effect of water deficits (rain fed). Importance of supplemental irrigation is emphasized by Babiker et al (2017) who indicated that ridge-furrow rainwater harvesting method can lessen the effect of water deficits (rain fed) throughout all crop growth stages, but water shortage would remain unavoidable during some stages of crop growth in arid and semiarid areas. Therefore, supplemental irrigation would still be needed to achieve a higher production.

Plant Height: It was indicated that the max height was reached with full irrigation and tied furrows and the least obtained by the traditional bain "terraces" system with rain fed irrigation. These results were in agreement with Babiker et al (2017) who reported highest yield was obtained in study for with Broad based furrows with full irrigation in study for evaluating micro-water harvesting techniques and water management methods for mitigating environmental degradation in rainfed Sesame production in dry lands of Sudan. Improvement in plant height can be ranked for watering systems in descending order as: (full irrigation > supplemental irrigation >rain fed irrigation).

Moisture Content: The capability of storing soil water (mm) by watering systems and harvesting techniques was indicated that the treatment of Full Irrigation with Tied Furrows resulted in conserving maximum soil moisture content while minimum moisture content was stored by basin with rain fed watering. The ability to store soil moisture was due to the characteristics and specification of the type of water harvesting technique and not affected by watering system. These results were supported by Teame et al (2021) who concluded as the effect of land configuration ways (flat, ridge and furrow, and bed furrow) on soil moisture and sesame seed yield in Ethiopia, that Sesame seed yield was easily affected by soil moisture stress due to reduced rain fall, and good vertisol management options that conserve moisture during dry spell period and drain excess moisture during wet periods was vital. Accordingly these results were supported using the ridge and furrow methods for conserving best soil moisture for highest plant and seed yield performance.

No Capsule/ plant: The Number of Capsule/ plant obtained with treatments of water harvesting technique and watering practice was shown. Performance of treatments with respect to mean number of capsule per plant given reflected that the maximum number was a result of full irrigation compared to other watering system due to its high soil water storage capability. However, in unexpected behavior the basin irrigation resulted in higher values.

Seed weight: Seed weight (gm) obtained with treatments of water harvesting technique and watering practice was depicted. It was evident that maximum seed weight was obtained by full irrigation with tied furrows while the minimum values resulted from semi-circular bund under rain fed watering system. Seed weight was a character related to availability of direct water with full irrigation and reflect no significant difference between water stored with tied furrows or basin water harvesting techniques.

Mean Yield: It was shown seed grain yield (Kg/ha) obtained with treatments of water harvesting technique and watering practice. These yield values were in agreement with Sarkar et al,. (2010). As expected availability of irrigation water by direct watering (full irrigation) and by water storage (with water harvesting method) resulted insignificantly maximum yield. This can be visualized from the typical yield ranking order with both watering method and harvesting techniques.

Conclusions

The obtained results showed that application of supplementary irrigation coupled with semi-circular bund could be an important climate change adaptation strategy in areas with variable rain amount and bad distribution.

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