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# The Impact of Intercropping between Maize and Soya Bean on Soil Moisture and Soil Temperature Related to Yield of Maize (*Zea mays* L.), River Nile State, Sudan

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**Abstract:** Intercropping has benefited the global agricultural sector in several ways. It is a critical farming practice for long-term productivity, agro-ecological improvement, land management and land use. It is a well-known method to increase soil health and crop productivity. Mixtures of cereals and legumes are used extensively for forage production. Mix between maize (*Zea mays*) and soya bean (*Glycine max* L.) was used to investigate intercropping effect on moisture and temperature of soil related to yield of maize. The experiment was carried out with randomized complete block design with four replications. The results showed that intercropping systems had non-significant effect on yield of maize. But it affected soil conditions especially between plant; and reduced soil temperature rang about 0.3-8 ℃ affected by treatment of soya bean sowing methods (W2) for both seasons. The percentage of soil moisture content was increased about 1%-18% in treatment W2. It was because of increase of percentage of canopy cover fraction by soya bean covered, the conditions area of maize was adapted to give chance for increased irrigation intervals of maize without making stress.

**Key words:** Irrigation intervals, canopy cover, cereals, legumes.

## 1. Introduction

Intercropping is an agricultural technique used to grow two or more different crops in alternate rows on a given plot of farmland at the same time during their growing season or in a growing period [1-3]. A tall crop is often intercropped with a short crop in this farming system, such as intercropping a legume and cereal [4].

Maize (*Zea mays*), which is the third most important cereal crop of world, it is an important source of carbohydrate in human diet in the developing world and as animal feed worldwide. It is more nutritious than rice. Soybean (*Glycine max* (L.) Merrill) is a leguminous oil crop, it is an important source of protein for man and animals.

Intercropping systems provide 15% to 20% of the world food supply [1]. It was reported by Xu et al. [5] that intercropping has been dubbed as the “new green revolution” because it is able to increase land efficiency by using information on how species complement one another and provide a way to achieve sustainable agricultural intensification. It has become the best cropping system for maize and soybean, and it also plays a critical role in contributing to modern and sustainable agriculture.

Cereal-legume mixtures are the most productive form of intercropping since the cereals may benefit from the nitrogen fixed in the root nodules of the legumes in the current year or in the subsequent years [4]. Maize-soybean intercropping may also be a way of saving irrigation water, especially in situations of

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limited water resources [6] as intercrops conserve water, largely due to an early high leaf area index and a high leaf area [7]. The incorrect selection of crops intercropping of incompatible species, can result in one crop completely suffocating the other; that is adverse effects (competition). The selection of hybrids and varieties is an extremely important issue, which depends mostly on the system and the aim of the intercropping [8, 9]. In additive intercropping, the selection of the major crop (due to interest in yields) is as important as the minor crop. A minor crop should be a variety that will not expose the major crop to competitive pressure.

Rainfall variability from season to season has been shown to reduce crop yields, especially in semi-arid region. Maize-soybean intercrops, which are the most prevalent in these areas, may not necessarily give the best returns in terms of yield or cash because farmers do not necessarily select the most compatible maize varieties for intercropping. Maize phenological development was not significantly affected by intercropping. High temperatures and water stress in dry areas could be inhibitory factors to establishment of rhizobia-legume symbiosis. Early maturing maize varieties could be less competitive than late maturity varieties for growth resources, which similarly influence rhizobia-legume symbiosis. Above-ground yields and grain yield of maize prolific hybrids are higher than standard hybrids in intercropping system, especially under favorable meteorological conditions including irrigation [9].

Cereal crops are considered as depleting of soil moisture and soil fertility according to soil fertility and crop rotation, sometimes it requires to add a large quantity of chemical fertilizers to compensate for the shortfall, but eventually lead to land degradation. This experiment will be executed for conservation of moisture, temperature and increase of soil fertility by the use of legume in intercropping system condition on yield of maize.

The objective of this study was carried out to investigate the impact of intercropping between maize and soya bean on soil moisture and soil temperature related to yield of maize.

## 2. Material and Methods

An experiment was conducted at Hudaiba Research Station farm (HRSF) in River Nile State, Sudan (latitude 17.57 ° N, longitude 33.93 ° E, altitude 350 m above sea level). Because the climate of the region is semi-desert, it is advisable to grow crops in the winter season. Experiment was conducted at seasons 2019/2020 and 2020/2021.

In this study the type of intercropping was relay intercropping; This involves planting one or more crops within an established crop in such a way that the final stage of the first crop corresponds with the initial growth stage of the other crop(s). In other words, a second crop is planted after the first has attained reproductive maturity or is close to maturity but is not yet ready for harvest [2, 10]. The experiment was executed on randomized complete block design (RCBD) with four replications, where four treatments included different methods of cultivated maize (Hudeiba2) and soya (Sudan-1), that is no intercropping (N), sowing of soya bean and maize at the same day (W), sowing of soya bean at one week before maize (W1) and sowing of soya bean at two week before maize (W2). The day for sowing maize was on second week of November and crop was sown as 2-3 seeds per hole at 20 cm intra-row spacing on the top of 60 cm ridges and the size of plots was 49 $m^2$. The irrigation intervals were every 15 days through the two crops' life cycle. The recommended dose of nitrogen (2N) was split into two doses: one at the second irrigation and the other after one month from sowing where the phosphorus (1P) in the form of Triple Super Phosphate was applied at sowing. The quantity of water applied to each irrigation was measured by using calibrated flow meter. For moisture content volumetric method by oven was used. Canopy cover was measured by photo to produce result by green crop tracker program. Recorded observations on various agronomical traits, five plants in each plot were selected

Soybean- maize: intercropping maize: no soybean

**Fig. 1 The intercropping and non-intercropping system**

at random and labeled to record the observations on various parameters. The data thus obtained were subjected to statistical analysis using analysis of variance to observe the significance of the treatment effect on a certain parameter.

## 3. Results and Discussion

### *3.1 Soil Temperature and Canopy Cover (CC)*

Tables 1 and 2 showed soil temperature effect by intercropping system, as soil temperature measured was reduced about 0.3-8 ℃ and 0.5-6 ℃ for two seasons respectively. Affected by soya bean treatment W2 had recorded lowest temperature compared with other treatments of W1, W and N (Figure.2).

Low temperature in soil was recorded compared with air temperature while canopy cover (CC) during initial and development stages was recorded an increase (Table 3). Affected by applied different intercropping system treatments, W2 (sowing of soya bean at the second week before maize) has high covered fraction by soya bean.

### *3.2 Percentage of Soil Moisture Content*

For soil moisture content measured before irrigation (pre) and after irrigation (post) at different depths (Figs. 3a-3d) and (Figs. 3e-3h) for two seasons respectively, the percentage of soil moisture content was increased about (1%-10%) and (2%-18%) for two seasons respectively. Highest value of soil moisture was recorded in Treatment W2 compared with W1 and W, while N recorded lowest value.

### *3.3 Yield and Yield Components*

Table 4 presents yield components and seed yield of maize as affected by intercropping system. There is no significant difference between parameters affected by treatments in all other traits for two seasons.

**Table 1 The impact of intercropping on soil temperature under the experiment at pre and post irrigation for season 2019/2020.**

| Date | Pre-irrigation temperature 2019/2020 | | | | | Date | Post-irrigation temperature 2019/2020 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Soil | | | | | Air | Soil | | | |
| | | Treatment | | | | | | Treatment | | | |
| | | N | W2 | W1 | W | | | N | W2 | W1 | W |
| 10/12/2019 | 32.6 | 31.1 | 29.4 | 30.8 | 30.3 | 16/12/2019 | 27.6 | 27.5 | 24.4 | 26.2 | 25.3 |
| 22/12/2019 | 26.4 | 26.4 | 24.2 | 26.1 | 24.5 | 31/12/2019 | 25.0 | 24.9 | 24.0 | 24.9 | 24.0 |
| 12/1/2020 | 26.6 | 22.0 | 21.2 | 21.6 | 21.2 | 15/1/2020 | 22.6 | 22.0 | 17.1 | 19.8 | 19.3 |
| 1/2/2020 | 30.0 | 22.7 | 22.1 | 22.2 | 22.1 | 17/2/2020 | 32.3 | 29.2 | 28.1 | 28.3 | 28.1 |

**Table 2 The impact of intercropping on soil temperature under the experiment at pre and post irrigation for season 2020/2021.**

| Date | Pre-irrigation temperature 2020/2021 | | | | | Date | Post-irrigation temperature 2020/2021 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Soil | | | | | Air | Soil | | | |
| | | Treatment | | | | | | Treatment | | | |
| | | N | W2 | W1 | W | | | N | W2 | W1 | W |
| 16/12/2019 | 27.6 | 27.5 | 24.4 | 26.2 | 25.3 | 27/12/2020 | 26.5 | 26.5 | 26.1 | 25.9 | 26.5 |
| 31/12/2019 | 25.0 | 24.9 | 24.0 | 24.9 | 24.0 | 11/1/2021 | 28.1 | 27.5 | 26.4 | 26.1 | 26.4 |
| 15/1/2020 | 22.6 | 22.0 | 17.1 | 19.8 | 19.3 | 31/1/2021 | 26.8 | 26.7 | 25.2 | 25.7 | 26.7 |
| 17/2/2020 | 32.3 | 29.2 | 28.1 | 28.3 | 28.1 | 16/2/2021 | 26.5 | 26.5 | 26.1 | 25.9 | 26.5 |
| | | | | | | 5/3/2021 | 29.0 | 29.0 | 28.1 | 28.6 | 28.0 |

**Table 3 Percentage of canopy cover fraction of soya bean plant analysis by green crop tracker program, for two seasons.**

| Stage | Canopy cover percentage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2019/2020 | | | | 2020/2021 | | | |
| | N | W | W1 | W2 | N | W | W1 | W2 |
| Initial | 27.5 | 27.6 | 27.6 | 31.7 | 7.0 | 9.0 | 13.0 | 16.0 |
| Development | 26.9 | 26.8 | 44.9 | 62.0 | 18.0 | 19.0 | 27.0 | 36.6 |

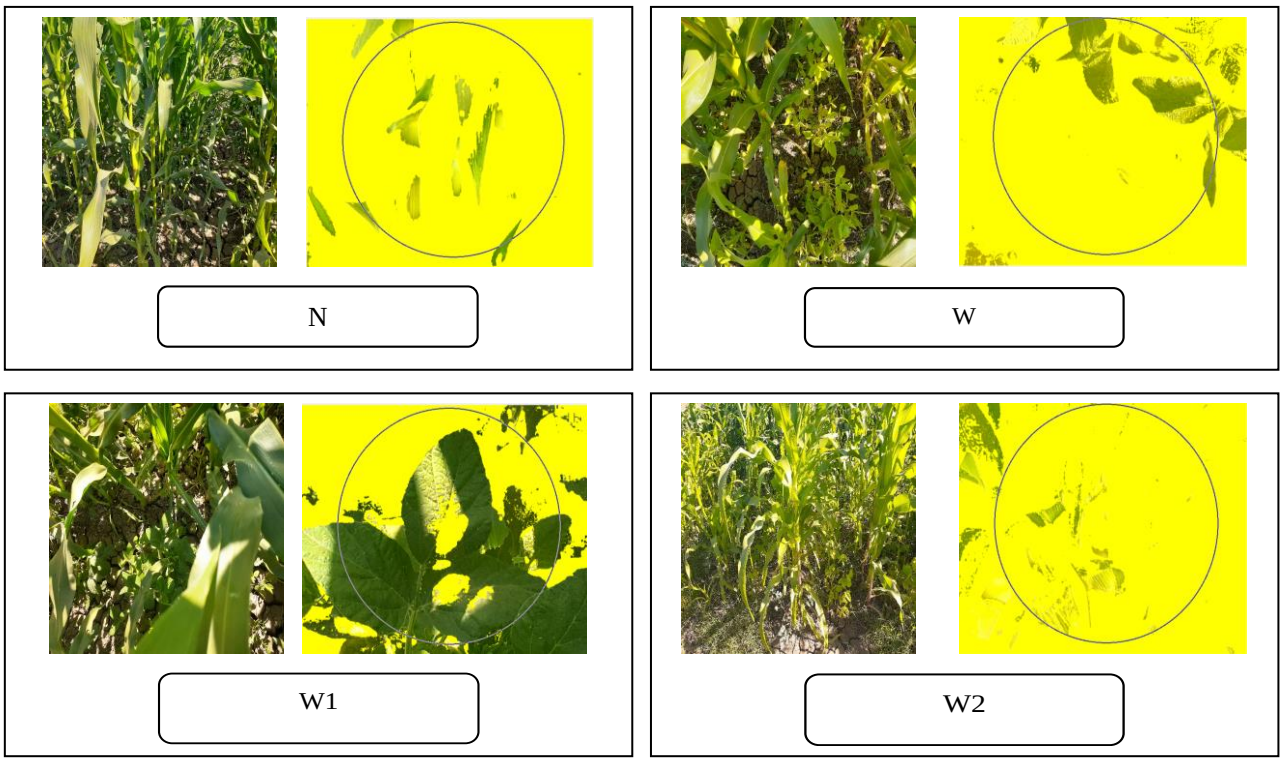



**Fig 2 Canopy Cover for different treatments by green crop tracker program**

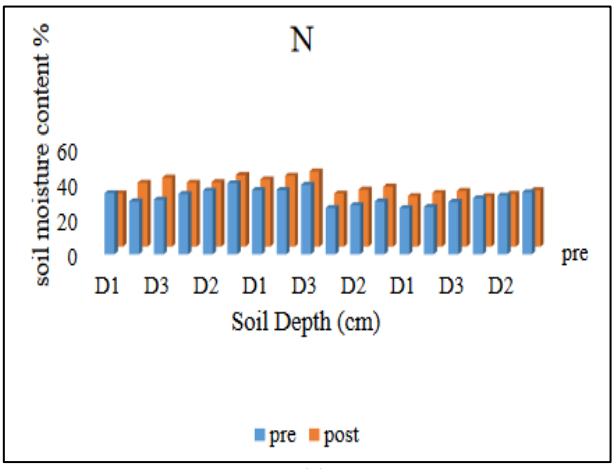
**Table 4 Effect of different intercropping system on yield and yield components of maize, for two seasons.**

| 2019/2020 | | | | | | |
|---|---|---|---|---|---|---|
| Treatments | Plant height (cm) | Cobs length (cm) | Cobs diameter (cm) | Seed per cobs (No.) | 100-kerenals (g) | Grain yield (t/ha) |
| N | 177 | 15 | 14 | 882 | 16 | 1.7 |
| W | 176 | 14 | 13 | 814 | 16 | 1.9 |
| W1 | 185 | 14 | 12 | 835 | 16 | 1.8 |

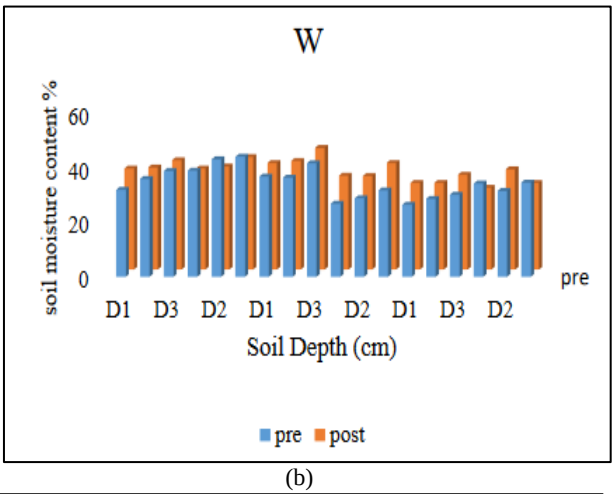
Table 4 to be continued

| | | | | | | |
|---|---|---|---|---|---|---|
| W2 | 176 | 14 | 12 | 810 | 15 | 2.2 |
| Means | 178 | 15 | 13 | 835 | 16 | 1.9 |
| SE ± | 4.41$^{ns}$ | 0.9$^{ns}$ | 0.3$^{ns}$ | 65.8$^{ns}$ | 1.064$^{ns}$ | 0.145$^{ns}$ |
| C.V. (%) | 4.9 | 11.8 | 5.2 | 15.7 | 13.6 | 15.4 |
| 2020/2021 | | | | | | |
| N | 189 | 16 | 14 | 466 | 26 | 3.7 |
| W | 188 | 16 | 14 | 475 | 26 | 3.9 |
| W1 | 184 | 16 | 13 | 438 | 25 | 3.4 |
| W2 | 192 | 16 | 14 | 447 | 26 | 3.9 |
| Means | 188 | 16 | 14 | 456 | 26 | 3.7 |
| SE ± | 5.75$^{ns}$ | 0.81$^{ns}$ | 0.11$^{ns}$ | 19.6$^{ns}$ | 1.05$^{ns}$ | 0.38$^{ns}$ |
| C.V. (%) | 4.3 | 7.2 | 1.1 | 6.1 | 5.8 | 14.5 |

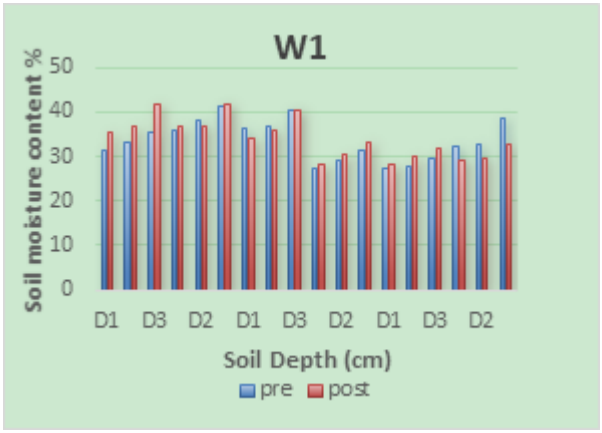
ns: No significant difference.



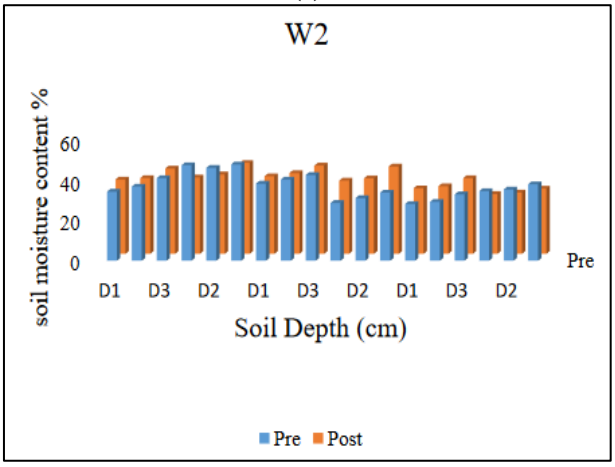

(a)




(b)




(c)




(d)

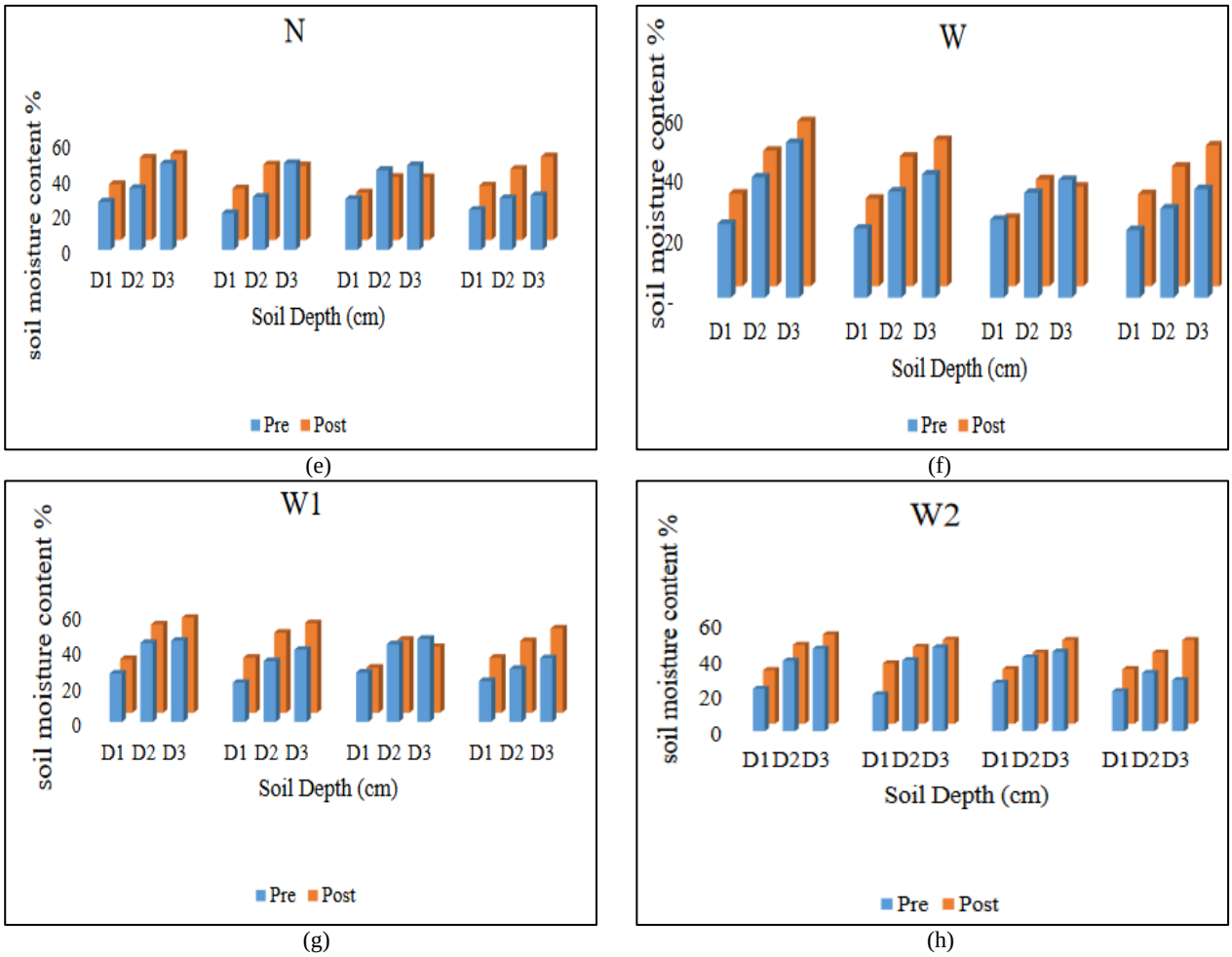



**Fig. 3 (a)-(d) The effect of intercropping on soil moisture content for 2019/2020; (e)-(h) soil moisture content for 2020/2021.** D1: 0-20; D2: 20-40; D3: 40-60.

## 4. Conclusion

There was no difference in corn productivity under the intercropping system between maize and soya bean but affected clearly the fixed condition area of maize. These conditions make low soil temperature and increase the percentage of soil moisture content through the maize obtained by treatment i.e., W2, sowing of soya bean at two weeks before maize.

When soil moisture content rises, the duration of maize irrigation intervals increases.

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