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*Full Length Research Paper*

# Response of maize and cucumber intercrop to soil moisture control through irrigation and mulching during the dry season in Nigeria

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**Replicate field plots were used in experiments aimed at evaluating the yield potentials of maize and cucumber intercrop resulting from the control of soil moisture through irrigation and mulching, for a period of eleven weeks. Three irrigation depths, 2.5, 3.5 and 4.5 mm; and two mulch levels, zero mulch and 10 ton/ha of oil palm bunch refuse as mulch material were employed, while the third option involved the combination of the different levels of irrigation and mulching. These were used alongside fertilizer application. The pertinent growth and yield parameters were then determined. Results of the analysis indicated that there were no significant differences in growth parameters such as plant height, vine length and days to 50% flowering across the treatment variants. Yield components such as total grain yield, total fresh cob yield and total fruit yield differed greatly across the treatment options and also indicated significance at the 1% probability level. It was observed that cucumber total fruit yield was greater in the plots that received only mulching than the other plots. The results of the study highlight the position that the best crop yields would be obtained for maize and cucumber intercrop during the dry season, if farmers resort to optimum application levels while using the synergy of irrigation and mulching to achieve a crop favorable soil moisture regime.**

**Key words:** Maize, cucumber, total fresh cob yield, total grain yield, total fruit yield, irrigation, mulching, oil palm bunch refuse, plant height, vine length.

## INTRODUCTION

Farmers in Nigeria and in many tropical countries mainly depend on rain fed agriculture for their cropping activities. This is anchored on the existence of two distinct weather seasons – rainy and dry seasons; hence cropping is skewed towards the rainy season when the high amount of rainfall is believed to be adequate to supply crop water needs. Unfortunately the soil condition in many parts of the country, especially in the Niger delta area where this study was carried out is such that the amount of gravitational water into the soils is usually very slow as a result of the poor permeability of the soils. This, coupled with the high evaporation which is about one half of the rainfall leads to a scenario in which only a small fraction of the observed rainfall actually infiltrates and percolates into the root zone to sustain plant growth (Fubara-Manuel, 2005). The result of the above has been low agricultural productivity thus contributing to the world food problem.

Maize and cucumber are two important food crops in Nigeria as well as in other parts of the world. Over the years maize has been useful as a food, feed, construction material, and fuel, medicinal or decorative plant. With the industrial development, it increasingly became an industrial raw material for the production of starch, gluten, oil, flour, alcohol and lignocelluloses for further processing into a whole range of products and by-products. On the other hand, cucumber is a major fruit

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vegetable that is eaten raw (in salad) or cooked. It can also be put in vinegar; the crop serves as a major source of vitamins for people in developing countries. In spite of their importance, these crops are still in low productivity owing to several factors but water has been observed to be the principal yield limiting factor (Ayotamuno et al., 2000).

The above informs the need for practices that guarantee the availability of moisture in the soil to meet crop water needs. This is where irrigation and mulching come in. While irrigation is aimed at increasing the available water for crop production, mulching conserves soil moisture as well as increases soil fertility, controls weeds and improves the soil's physical condition. However, in Nigeria and indeed many tropical countries, very few are the farmers who practice mulching, amidst its high advantages. Consequently, the present study sought to investigate the response of two commonly grown crops in the study area to the soil moisture control practices using the inter-cropping system which occupies a great percentage of cultivated land in West Africa (Wahua, 1986). The choice of the intercropping system stems from its adventages which include: reduction of susceptibility to diseases and pests, allowance for adaptation of plants to changing soil conditions because of differences in peak demand by associated crops for nutrient and water, among other things.

The purpose of the study was to investigate the yield potentials of both crops resulting from the combination of both practices as well as comparing that to the result of using either of them (irrigation/mulching); in a bid to ascertain application levels that are favorable during the dry season in the study area. This stems from the fact that the dry season, though unfavorable with regards to crop water requirements has relatively more conducive conditions for crop production by reason of its adequate temperature to support plant growth and low incidence of pests, diseases and weeds due to the absence of rains. It was also the objective of the study to analyze the effect of the mulch material on some selected soil properties especially the ones that affect soil moisture condition and growth/yield potential with the aim of assessing its utility in soil moisture control.

## MATERIALS AND METHODS

### Study area

The study was conducted at the Teaching and Research farm of the Rivers State University of Science and Technology, Port Harcourt, Nigeria between the months of January and March 2005. The study area is characterized by the tropical rain forest vegetation, with a rainfall depth ranging from 2000 – 2484 mm per annum, of which 70% occur between the months of May and August. The rest of the year is relatively dry. Mean temperature varies from 24 to 30°C (Ayotamuno et al., 1997). The soil type is ultisol (USDA classification) and its texture is sandy loam.

### Experimental design

The design of the experiment was a factorial design fitted into randomized complete block with three replications. The size of each plot was 5 m x 5 m. The experimental set up consisted of plots with three irrigation depths viz: 2.5, 3.5 and 4.5 mm. Two mulch levels (zero level mulch and 10 ton/ha mulch) were used. The zero level mulch plots served as a 'representative control' as it represented the natural condition of the soil during the dry season since the plots were neither irrigated nor mulched. The remaining plots received a combination of 10 ton/ha mulch and the three variants of irrigation depths.

### Planting

The test crops; maize (OBA SUPER 2 hybrid) and cucumber (Danish seed) were planted at 1 m x 1 m spacing at four (4) seeds per hole for maize, and three seeds per hole for cucumber. The maize plants were thinned to two plants per stand after germination.

### Treatment applications

**Irrigation:** The various irrigation levels were applied as surface irrigation in the field by measured application using watering cans. The three irrigation depths were applied on a daily basis. The choice of these application depths emanated from the findings of Ayotamuno et al. (2000) which had it that application levels in the order of 3.5 to 8.5 mm per day could yield great returns for maize during the dry season in the study area.

**Mulching:** This was done using partially decomposed oil palm bunch refuse. It was applied five days after planting. At application the moisture content of the mulch was 46% by weight, wet basis.

### Laboratory methods

This was done on the basis of assessing the influence of the mulch material on selected soil properties. Hence soil samples were collected from the plots with zero mulch and 10 ton/ha mulch treatment only. Properties determined include soil texture, moisture content, organic carbon and total nitrogen content, available phosphorus and soil pH. This was done using methods adapted from relevant literatures (Black et al., 1965; Jackson, 1964; Bremner, 1965). In order to achieve the above, soil samples were augured randomly from different spots on the plots at two depths, 0 – 15 cm and 15 – 30 cm. The soil samples were immediately transferred to the laboratory for analysis.

The chemical properties of the oil palm bunch refuse (i.e. mulch material) were determined by digesting the refuse first before analyzing for the various properties, in exception of the analysis for sodium which was done in the same way as the soil properties. The chemical properties are as shown in Table 1.

### Weeding and fertilizer application

The first weeding was done manually three weeks after planting (3 WAP) in all the plots, thereafter weeding was done at three weeks interval to keep the plots weed free throughout the study period. A compound fertilizer, 15:15:15 N: P: K was applied as a single dose at the rate of 400 kg/ha. This was done at the third week after planting in the aftermath of weeding.

**Table 1.** Chemical properties of oil palm bunch refuse.

| pH | % | | C/N ratio | Available P ( mg/kg) | Exchangeable bases (C mol/Kg) | | | |
|---|---|---|---|---|---|---|---|---|
| | Organic C | Total N | | | K | Ca | Mg | Na |
| 8.00 | 3.18 | 0.30 | 10.60 | 10.97 | 0.06 | 6.20 | 4.10 | 0.44 |

**Table 2.** Maize plant height and leaf area, 11 WAP (mean ± standard deviation of three replicates).

| Parameter | Irrigation depth ( mm) | | | Mulch level ( ton/ha) | | Mulch (10 ton/ha) and irrigation (mm) | | |
|---|---|---|---|---|---|---|---|---|
| | 2.5 | 3.5 | 4.5 | 0 | 10 | 2.5 | 3.5 | 4.5 |
| Maize plant height (m) | 1.24 ± 0.03 | 1.55 ± 0.07 | 1.84 ± 0.05 | 1.48 ± 0.08 | 1.63 ± 0.08 | 0.92 ± 0.07 | 1.13 ± 0.09 | 1.41 ± 0.11 |
| Maize leaf area ($cm^2$) | 539.00 ± 4.47 | 543.72 ± 4.89 | 560.75 ± 008 | 531.62 ± 0.06 | 545.61 ± 0.07 | 419.37 ± 62.43 | 413.62 ± 60.20 | 415.87 ± 23.67 |

### Growth parameters

**Plant height:** This was taken from a sample of four plants (maize) tagged within the two central rows of each plot. The mean from the four plants was then determined.

**Vine length:** The vine length of cucumber was measured within the two central rows for four plants and the mean determined for computation.

**Leaf area:** The leaf area was determined by the non destructive length x width method described by Saxena and Singh, (1985) using the relation:

Leaf area = 0.75 (length x width), where 0.75 is a constant.

Five leaves were measured for each treatment plot and the mean leaf area determined. The leaf area for cucumber was measured by the girth system whereby graph sheets were used to trace the area (surface) of five leaves in each treatment plot and the mean determined.

**Days to 50% flowering:** The effect of treatment on the flowering period of maize and cucumber were measured by recording the days from planting to when 50% of both plants flowered.

### Yield parameters

**Number of fruits per plant:** This was recorded by counting the number of fruits harvested from a plant.

**Number of seeds per cob:** Five maize cobs from each treatment plot were allowed to dry in the field to 14% moisture content and then harvested. The seeds were removed from the cobs and counted. The mean was then determined.

**Fruit weight:** Five cucumber fruits from each treatment plot were weighed separately and the mean determined. Also, weekly harvest totals were recorded for analysis.

**Fresh cob weight:** Five fresh maize cobs from each treatment plot were weighed separately and the mean determined. This was done to give a good estimate of the total yield of fresh maize.

**1000 seed weight:** The weight of 1000 seeds was recorded for each treatment plot and used for computation. This was done using the dry seeds obtained from the maize cob.

**Total grain yield:** After counting the dry seeds, the total grain yield at 14% moisture content was determined for each plot, extrapolated and recorded in tons /ha.

### Data analysis

This involved simple univariate summary statistics such as the mean and standard deviation. The data collected were subjected to analysis of variance following the procedure described by Frank and Althoen (1994). The analysis was used to compare the variability in selected growth and yield parameters, due to the treatment applications, 11 WAP. The data for the highest variants of the treatment applications were the ones utilized for the evaluation of the differences in the selected parameters during the course of the analysis.

## RESULTS AND DISCUSSION

The effect of the treatment applications (irrigation, mulching and the combination of both treatments) on maize growth parameters is as shown in Table 2. At the end of eleven weeks after planting (11 WAP), the maximum plant heights were 1.24, 1.55 and 1.84 m for irrigation levels of 2.5, 3.5 and 4.5 mm respectively. This confirmed the findings of Ayotamuno et al. (1997) and Abdullah et al. (2004) that growth in maize is highly related to irrigation depth and it increases with increasing irrigation water. The mulched plots had higher growth than the unmulched plots and also revealed plant heights (mean, 1.63 m) greater than the two lesser irrigation depths (2.5 and 3.5 mm) but lower than the highest depth used (4.5 mm). However, it was observed that the effect of combining mulch and irrigation did not give better results in plant height as compared to the use of either irrigation or mulching. In fact, the highest irrigation depth combined with the 10 ton/ha mulch resulted in a plant height of

**Table 3.** Cucumber vine length and leaf area, 11 WAP (mean ± standard deviation of three replicates).

| Parameter | Irrigation depth (mm) | | | Mulch level (ton/ha) | | Mulch (10 ton/ha) & irrigation (mm) | | |
|---|---|---|---|---|---|---|---|---|
| | 2.5 | 3.5 | 4.5 | 0 | 10 | 2.5 | 3.5 | 4.5 |
| Cucumber vine length (m) | 2.35 ± 0.02 | 2.37 ± 0.01 | 2.43 ± 0.02 | 2.38 ± 0.02 | 2.40 ± 0.04 | 2.28 ± 0.02 | 2.31 ± 0.09 | 2.37 ± 0.02 |
| Cucumber leaf area ($cm^2$) | 452.41 ± 1.86 | 456.12 ± 2.62 | 460.75 ± 1.08 | 513.08 ± 2.25 | 517.62 ± 7.29 | 398.88 ± 3.96 | 406.38 ± 1.93 | 405.50 ± 1.60 |

**Table 4.** Yield indices of maize and cucumber, 11 WAP (mean ± standard deviation of three replicates).

| Crop | Yield index | Irrigation depth (mm) | | | Mulch level (ton/ha) | | Mulch (10 ton/ha) & irrigation (mm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2.5 | 3.5 | 4.5 | 0 | 10 | 2.5 | 3.5 | 4.5 |
| Maize | Fresh cob weight (kg) | 0.30 ± 0.01 | 0.32 ± 0.01 | 0.35 ± 0.01 | 0.32 ± 0.01 | 0.32 ± 0.01 | 0.31 ± 0.02 | 0.33 ± 0.02 | 0.36 ± 0.02 |
| | Number of seeds per cob | 328± 24.02 | 361± 25.08 | 401± 23.47 | 354± 20.01 | 374± 14.32 | 365± 18.56 | 380± 20.11 | 421± 15.60 |
| | 1000 seed weight | 165 ± 5.43 | 207 ± 3.09 | 242 ± 4.33 | 193 ± 7.53 | 215 ±10.14 | 185 ± 2.69 | 220 ± 3.44 | 251 ± 3.36 |
| | Total fresh cob yield (ton/ha) | 5.84 ± 0.14 | 6.99 ± 0.21 | 7.85 ± 0.17 | 6.62 ± 0.29 | 7.07 ± 0.32 | 7.05 ± 0.26 | 8.10 ± 0.21 | 8.75 ± 0.16 |
| | Total grain yield (ton/ha) | 2.23 ± 0.80 | 2.56 ± 0.18 | 4.13 ± 0.13 | 2.31 ± 0.21 | 3.40 ± 0.24 | 2.90 ± 0.19 | 3.19 ± 0.24 | 4.65 ± 0.23 |
| Cucumber | Number of fruit per plant | 2 ± 0.38 | 2 ± 0.01 | 3 ± 0.47 | 2 ± 0.50 | 3 ± 0.51 | 3 ± 0.50 | 3 ± 0.55 | 4 ± 0.48 |
| | Total fruit yield (ton/ha) | 3.28 ± 0.08 | 3.93 ± 0.12 | 4.41 ± 0.10 | 3.43 ± 0.10 | 8.84 ± 0.42 | 4.25 ± 0.24 | 5.00 ± 0.40 | 5.38 ± 0.27 |

1.41 m which is lower than the values reported above. Nevertheless, the one-way analysis of variance (ANOVA) indicated that there was no significant difference in plant height due to the treatment applications (Table 6). This implies that the treatments only brought about variations in soil moisture which was not adequate to induce significant differences in maize plant height.

The leaf area of maize also showed the same trend discussed above. The plants showed increasing values of leaf area with increasing irrigation depth; the mulched plot had a bigger leaf area than the un-mulched plots, while the use of either of the treatments resulted in bigger leaf areas than the combination of both treatments (Table 2). Similarly, cucumber leaf area responded to increasing irrigation depth with a corresponding increase in leaf area (452.41 – 460.75 $cm^2$ for 2.5 – 4.5 irrigation depth) (Table 3). However, in the mulched plots cucumber had an increased leaf area than the un-mulched plots, but this time the leaf areas recorded were far greater than the ones in the irrigated plots. This distinct variation may be attributed to the peculiar consumptive use and/or nutrient utilization of cucumber with respect to leaf area development, since increase in leaf area is a growth phenomenon which is affected by increase in nutrients especially nitrogen in the soil. Comparing the results in Tables 1 and 7, it can be deduced that the nitrogen rich-mulch material increased the total nitrogen content of the soils in the mulched plots; this probably accounts for the bigger leaf areas in the mulched plot. Furthermore, cucumber vine length showed a strikingly similar trend to that discussed above for maize plant height (Table 3), with the statistical analysis indicating that there were no significant differences between treatment applications at the 10% probability level. This further buttresses the position that the treatments did not produce any significant difference in the linear dimensions of the crops (maize and cucumber).

On the other hand, maize yield components had a different trend as such parameters as fresh cob weight, number of seeds per cob, 1000 seed weight, total fresh cob yield and total grain yield responded distinctly to the treatment applications. All five parameters increased with increasing irrigation depth; just as the mulched plots had higher values of the yield indices than the un-mulched plots. Of primary interest here is the observation that the aggregate effect of mulch and irrigation resulted in higher values of the yield indices than the effects of either irrigation or mulching (Table 4). This agrees with Ayotamuno et al. (2000) that though many factors serve to limit crop growth including soil types, nutrient contents, and climate, water has been observed to be the principal yield limiting factor. The yield indices of cucumber (number of

**Table 5.** Number of days to 50% flowering (Mean ± standard deviation of three replicates)

| Crop | Irrigation depth (mm) | | | Mulch level (ton/ha) | | Mulch (10 ton/ha) &Irrigation (mm) | | |
|---|---|---|---|---|---|---|---|---|
| | 2.5 | 3.5 | 4.5 | 0 | 10 | 2.5 | 3.5 | 4.5 |
| Maize | 65 ± 1 | 63 ± 1 | 61 ± 1 | 63 ± 1 | 62 ± 0.58 | 64 ± 0.58 | 62 ± 0.10 | 60 ± 1 |
| Cucumber | 44 ± 1 | 42 ± 1 | 40 ± 1 | 42 ± 1 | 41 ± 0.58 | 44 ± 0.58 | 42 ± 0.58 | 40 ± 0.58 |

**Table 6.** Summary of the Analysis of variance (ANOVA).

| Parameter | Source of variability | S.S | d.f | M.S | F value |
|---|---|---|---|---|---|
| Plant height (m) | Among groups | -15.793 | 2 | -7.9000 | -3.62 $^{ns}$ |
| | Within groups | 13.103 | 6 | 2.1800 | |
| | Totals | 2.690 | 8 | | |
| Cucumber vine length (m) | Among groups | 0.005 | 2 | 0.0025 | 3.13 $^{ns}$ |
| | Within groups | 0.005 | 6 | 0.0008 | |
| | Totals | 0.010 | 8 | | |
| Total grain yield (ton/ha) | Among groups | 2.368 | 2 | 1.1840 | 28.19 ** |
| | Within groups | 0.250 | 6 | 0.0420 | |
| | Totals | 2.618 | 8 | | |
| Total fresh cob yield (ton/ha) | Among groups | 4.241 | 2 | 2.1210 | 40.55 $^{+}$ |
| | Within groups | 0.314 | 6 | 0.0523 | |
| | Totals | 4.555 | 8 | | |
| Total fruit yield (ton/ha) | Among groups | 32.537 | 2 | 16.2685 | 193.90 $^{+}$ |
| | Within groups | 0.5036 | 6 | 0.0839 | |
| | Totals | 33.041 | 8 | | |
| Days to 50% flowering | Row | 1901 | 1 | 1901 | 5.73 * |
| | Column | 3 | 2 | 1.5 | 0.005 $^{ns}$ |
| | Interaction | 96028 | 2 | 48014 | 144.6 $^{+}$ |
| | Error | | 12 | | |

$^{ns}$Not significant at the 0.1 level.
*Significant at the 0.05 level.
**Significant at the 0.001 level.
$^{+}$Significant at the 0.0005 level

fruit per plant and total fruit yield) followed a similar trend. The highest number of fruit per plant was four (4) and it came from the plots that received the combination of mulch and irrigation treatments. However, the total fruit yield did not strictly follow the trend. The highest value of fruit yield was obtained in the 10 ton/ha mulched plots (8.84 ton/ha) (Table 4) which transcended the value (5.38 ton/ha) obtained in the plots given the combination of irrigation and mulching. Such a result was probably anticipated by Beets, (1981) who concluded that better yields can be obtained for crops with mulching since it is a practice for sustainability of farming systems in the tropics. All in all, it stands to reason that greater fruit yield of cucumber is better achieved with just mulching (especially when done with the mulch material used in this study) than the combination of the practice with much of irrigation water. However, the exact reason(s) why the mulched plots had better results than that of the plots combining irrigation and the same level of mulching remains not well understood. Statistical analysis showed that there were significant differences in total grain yield, total fresh cob yield and total fruit yield due to the treatment applications. These were significant at the 0.001, 0.0005 and 0.0005 probability levels for total grain yield, fresh cob yield, and fruit yield respectively (Table 6).

The results for the number of days to 50% flowering are as shown in Table 5. It is evident from the results that lesser days to 50% flowering can be achieved with increased irrigation depth and also increased application levels in the combination of irrigation and mulching. The two-way ANOVA employed indicated significance for the row and interaction sources of variability but there was no significance for the column source of variability (Table 6). This implies that the kind of plant determines the number of days to 50% flowering, and that maize and cucumber have different profiles of variations in days to 50% flowering across the three treatments. This is common sense as the crops belong to two different families of plants.

Table 7 shows the effect of the mulch material (oil palm

**Table 7.** Physicochemical properties of the soils in the mulched and un-mulched plots.

| Time | Plot | Sampling depth (cm) | pH 1:2.5 | % | | Available P ( mg/kg) | Exchangeable base (C mol/kg) | | | | % | | | % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Organic C | Total N | | Ka | Na | Ca | Mg | Sand | Silt | Clay | WHC | MC |
| Before experiment | General | 0 - 15 | 4.20 | 1.25 | 0.07 | 42.20 | 0.14 | 1.23 | 1.20 | 0.55 | 76 | 11 | 13 | 62 | 18.09 |
| | | 15 - 30 | 4.40 | 1.02 | 0.06 | 113.90 | 0.13 | 1.65 | 1.30 | 0.46 | 68 | 9 | 23 | 58 | 13.05 |
| After experiment | Mulched | 0 - 15 | 5.40 | 1.86 | 0.10 | 56.46 | 1.38 | 0.97 | 1.85 | 1.03 | 77 | 15 | 8 | 70 | 18.09 |
| | | 15 - 30 | 5.20 | 1.58 | 0.08 | 62.38 | 0.97 | 1.32 | 1.52 | 0.88 | 70 | 10 | 20 | 75 | 15.76 |
| | Unmulched | 0 - 15 | 4.80 | 1.32 | 0.07 | 41.20 | 0.98 | 0.97 | 1.06 | 0.08 | 76 | 11 | 13 | 70 | 18.03 |
| | | 15 - 30 | 4.60 | 1.16 | 0.06 | 52.48 | 0.97 | 0.53 | 1.00 | 0.06 | 68 | 9 | 23 | 75 | 15.67 |

WHC – water holding capacity.
MC – moisture content.

bunch refuse) on some soil physicochemical properties. One of such was the increment in soil pH thus reducing the original soil acidity which is characteristic of the soils in Southern Nigeria. The organic carbon and total nitrogen contents were also improved leading to favorable carbon-nitrogen (C/N) ratios for crop production. It also modified other soil properties like available phosphorus and exchangeable bases (potassium, sodium, calcium and magnesium) (Table 7). However, it had no effect on the water holding capacity of the soil. The last column of Table 7 shows that the mulch material was good at conserving available soil moisture. This is evident when the percent by weight moisture content of the un-mulched plots and the mulched plots are compared. The 'fairly constant' values in the two layers of the soil in both options is a pointer to the fact that the increment in soil moisture during the experiment due to rainfall was conserved by the mulch material, little wonder the slightly higher values in the mulched plots than the un-mulched plots. All in all, these may serve as indicators that highlight the utility of oil palm bunch refuse as a good mulch material for similar soil conditions.

## Conclusions

The results of this study confirmed the position that soil moisture can be controlled in order to favor plant growth and yield through irrigation and mulching during the dry season in Nigeria. Moreover, the study highlighted the position that the linear dimensions (or growth parameters) of maize and cucumber do not respond significantly to variations in soil moisture induced by different levels of irrigation and mulching. This by extension implies that not-so-large variations in soil moisture do not significantly affect the growth parameters used in the study. However, the yield of the crops; precisely, the total grain yield, total fresh cob yield and total fruit yield, are quite sensitive to variations in soil moisture. Hence attention has to be given to the control of the moisture level in the soil to optimum, through appropriate mechanization of the treatments, in order to achieve the best yields.

The findings of the study further revealed that mulching (with oil palm bunch refuse) induces higher cucumber fruit yield than the use of just irrigation. This paper therefore ends with the position that for greater yields of maize and cucumber in the dry season, particularly in the study area, optimum levels of irrigation and mulching has to be employed, and it is pertinent that farmers resort to the use of the synergy of both practices in order to achieve better soil moisture regime for crop yield. Further studies may continue along the lines of investigating the optimum application level(s) of the mulch material, which gives the best results.

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