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RESEARCH PAPER

Optimizing organic manure and plastic mulching to improve cucumber performance, soil water and thermal conditions of an Alfisol in a humid and tropical region

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Key Message: Combining poultry manure with plastic mulching optimizes cucumber production in humid tropical regions by improving soil water retention, regulating soil temperature, and enhancing growth and yield. This approach increases fruit numbers, water use efficiency, and overall yield, offering a sustainable solution for cucumber farming.

Abstract

A field experiment was conducted during the 2022 dry season to investigate the effect of organic manure and plastic mulch on soil water and thermal regimes and cucumber growth, yield and water use efficiency at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti southwest Nigeria. The experiment was 2- factorial, laid out in randomized complete block design (RCBD) with four replications. The organic manure factor consisted of poultry, piggery and no manure while the mulching factor comprised black plastic mulch and no mulch. Soil water content and temperature of the 0 - 10 and 10 - 20 cm layers of the field were monitored while cucumber growth parameters, yield components and water use efficiency data were also collected. Soil temperature was significantly ($p < 0.05$) higher in mulch treatment compared to no mulch treatment in both 0 - 10 cm surface and 10 - 20 cm subsurface soil layers. Conversely, organic manure did not affect ($p > 0.05$) soil temperature although it was highest in no manure treatment. Mulching significantly ($p < 0.05$) increased soil water content while poultry manure treatment had the highest soil water content during the growing cycle. Mulching significantly ($p < 0.05$) increased the number of leaves, leaf area and vine length of cucumber. Both organic manure and mulching significantly ($p < 0.05$) influenced leaf temperature, number of fruits but not fruit length, fruit diameter, yield and water use efficiency. Furthermore, the combined application of plastic mulch and poultry manure gave the highest yield and water use efficiency of cucumber. It showed that combined poultry manure and plastic mulch could be an ideal combination for soil and water management and conservation for sustainable cucumber production in this area. © 2024 The Author(s)

Keywords: Cucumber productivity, Mulching, Organic amendment, Soil temperature, Soil water content

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Introduction

Cucumber (*Cucumis sativus* L.) belongs to *Cucumis* genus in *Cucurbitaceae* family and fruit vegetables which is cultivated in temperate and tropical regions throughout the world (Vora, 2014). The total production of cucumber was 87,805,086 tons worldwide and Asia is the largest producer, accounting for 84.9% of the world's total production in 2019 (FAOSTAT, 2019). Presently, cucumber is the fourth most widely cultivated vegetable after tomato, cabbage and onions (Jamir & Sharma, 2014). In Nigeria, cucumber is produced during both rainy and dry seasons however, production is always low during the dry season making it difficult to meet demand during the dry season. Cucumber has abundant water, nutrients and phytochemical composition, and it possesses versatile uses in culinary, therapeutic and cosmetic purposes (Mukherjee et al., 2013). Despite these advantages, cucumber plant is sensitive to water stress because the root system is shallow, concentrating in the surface layer (Kirnak & Demirtas, 2006; Hashem et al., 2011). Furthermore, cucumber is a heavy feeder of soil nutrients requiring well-drained and nutrient-rich soils. Okafor and Yaduma (2021) highlighted some factors limiting the cucumber production on Nigerian soils including low fertility, slope, poor effective depth, stoniness or high gravel content and low moisture retention. Therefore, strategies to conserve water in the surface layer where the cucumber root is concentrated as well as ensuring adequate supply of soil nutrients are needed.

Mulching is a soil management practice aimed at conserving water, increasing soil moisture regime by reducing evaporation loss from the soil surface (Abbas & Shafique, 2019; Abbas, 2022). Mulching is any covering materials including organic (grass, sawdust or straw) or inorganic materials (textile, films of metal or plastic) on the soil surface (Snyder et al., 2015). The modification of the soil microclimate by plastic mulching has been reported to favour seedling emergence by increasing or decreasing soil temperature, conserving soil water through reduced evaporation and suppressing weeds (Olabode et al., 2007; Snyder et al., 2015; Tegen et al., 2015; Zhang et al., 2017; Laulina & Hasan, 2018; Mkhabela et al., 2019; Mzabri et al., 2021; Shilpa et al., 2021). Soil nutrients management is an important aspect in crop production and ensuring balanced soil nutrients has become a major task for farmers (Ahmad & Aslam, 2018; Mehmood et al., 2022; Azam et al., 2023). Nitrogen, phosphorus and potassium are the essential micronutrients required for proper growth and development of crops and they have become yield-limiting factor in most agricultural fields especially in areas with low soil organic matter content (Liliane & Charles, 2020). Organic manure does not only supply nutrients, it also improves the soil structure by promoting aggregation and enhancing water retention through increased pore space (Mujdeci et al., 2019).

Soil water and nutrients availability are key factors for crop production. Several studies have evaluated the effects of different organic amendments and mulching on soil conditions, crop growth, yield and water use efficiency (Yaghi et al., 2013; Xiukang et al., 2015; Al-Amin et al., 2017; Dong et al., 2018; Kumar et al., 2019; Adekiya et al., 2021; Hague et al., 2021; Mak-Mensah et al., 2021; Sharma et al., 2021; Hossain et al., 2022; Liu et al., 2023) however only the studies of Al-Amin et al. (2017); Mak-Mensah et al. (2021) considered the integration of the two factors while such study has not been documented in Ado Ekiti, southwest Nigeria as cucumber production is just gaining prominence in Ekiti state. Thus, optimizing organic manure and mulching is crucial for adopting them as a management tool for boosting cucumber yield, better nutrient and water use efficiencies as well as improving soil physical quality. The objective of this study therefore was to evaluate the effects of organic manure and plastic mulching on the performance of cucumber (*Cucumis sativus* L.), soil water content and thermal regimes under open-field conditions in Ado Ekiti, southwest Nigeria.

Materials and Methods

Study area

The study was carried out at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Southwest Nigeria during the 2022 dry season. The site is located on Longitude 4°45' to 5°45' E and Latitude 7°15' to 8°5' N at 434 m above sea mean level in the humid, tropical climate distinguished by dry and wet seasons with a total annual rainfall of about 1367.7 mm. The average daily temperature is almost uniform throughout the year with little deviations from 27 °C. The Soil of the study site belongs to the broad group of Alfisol, classified as Typic Kandipludalf (Soil Survey Staff, 2014) with top sandy-loam to clay texture (Fasina et al., 2005). Pepper, maize, tomato, amaranth, and garden egg have been grown on the site and left to fallow for two years before the installation of the experiment. Some soil physico-chemical properties of the 0-30 cm layer are presented in Table 1. The loamy sand texture meets the soil requirement for cucumber production in this region.

Experimental design and treatments

The study was 2- factorial experiment, laid out in randomized complete block design (RCBD), replicated four times. The two factors are: organic manure at three levels namely: poultry (Po), piggery (Pi) and no manure (control (Co) and mulching at two levels namely: plastic mulch (M) and no mulch (NM).

Land preparation, field layout and installation of drip irrigation and plastic mulch

The site was cleared of existing vegetation and the packing of debris before the marking out into plots. Tilling of soil and making of ridges were done with the use of hoe and spade. Poultry manure (Po) and piggery manure (Pi) at the rate of 10 tons/ha (Odeleye et al., 2008) were spread evenly to the soil surface, mixed and incorporated manually within the 10 cm soil depth. There were four (4) blocks and each block was divided into six (6) plots, each plot was a ridge, 4 m long. The field layout is shown in Fig. 1. The drip irrigation system, adopted from Awe et al. (2017), consisted of Netafim drip tapes (pressure-compensating type, 4 L/h discharge rate and 30 cm interval between drip points). Non pre-perforated plastic mulch, cut to 4 m long and 1.5 m wide, was placed to cover the ridges, designated as mulched. To create planting points on the covered ridges, the plastic mulch was perforated at each drip emitter point using scissors.

Planting and field management

Prior to planting, the field was adequately irrigated for two (2) days. Cucumber seed (Variety: African Giant, CU 999) was obtained from a government accredited seed company. One (1) seed of cucumber was planted at a spacing of 30 cm along the drip line on the ridges spaced 1-m apart, giving a plant population of about 33,333 plants per ha. After planting, the field was irrigated uniformly for 10 days for crop establishment after which the irrigation treatments were imposed. Weeding was done manually by uprooting and hoeing. At two (2) weeks after planting, soluble fertilizer, KNO_3, at the rate of 50 g KNO_3/ 25 L H_2O was applied via the irrigation water. Foliar fertilizer, Agrovert (NPK 20-20-20 + TE) was also applied at the rate of 50 g/16 L H_2O on weekly basis. Insecticide (Laraforce Gold) and fungicide (Red Force (metalaxyl + Copper Oxide) + Ridomil) were applied to combat insect pests and control fungal attack, respectively. Staking and training of the cucumber were done from three weeks after planting to protect the fruits from contact with the soil, ensure good aeration within the crop canopy and ensure a good yield (Modupeola et al., 2016).

Soil sampling and laboratory analysis

Shortly after seedbed preparation, a mini profile, about 40 cm deep, was dug at the center of the experimental site for soil sampling. Structured soil samples was collected from the center of soil layers 0 - 10, 10 - 20, and 20 - 30 cm layers using core samplers 57 mm diameter and 40 mm high. Disturbed soil samples were collected from same soil layers and transported to the laboratory for routine analysis of soil physical and chemical properties. In the laboratory, the disturbed soil samples was air-dried, crushed and sieved to remove materials larger than 2 mm with the aid of 2-mm sieve while the structured samples was trimmed to remove excess soil. The samples were analyzed for soil physical and chemical properties following standard laboratory procedures.

Data collection

Soil temperature

Soil temperature of the 0 - 10 and 10 - 20 cm layers was monitored in the morning (08:00 - 10:00 h) using digital-type, 4-in-1 soil thermometer. A 12 h by 1-hr interval leaf temperature was measured in a day during the growing cycle to evaluate the diurnal changes in soil temperature. Air temperature was also measured alongside the leaf temperature.

Soil moisture content

Soil water content of the 0 - 10 and 10 - 20 cm layers was monitored using a digital soil moisture meter (Model: PY 1005, China).

Plant growth parameters

Vine length was measured using a flexible tape rule from the soil surface to the tip of the vine. Stem girth was determined using a digital-type vernier caliper while the leaf area was obtained as 0.75 × leaf length × leaf breadth (Abegunrin et al., 2013).

Yield and yield components

All the cucumber plant stands in each experimental unit was used for the yield analysis. Cucumber harvesting started at about 40 days after planting and this was done every 3 days interval for 40 days. Number of fruits was the sum of fruits harvested during the harvest period. Fruit length and fruit diameter were obtained using flexible steel tape and vernier caliper, respectively. Fruit weight was obtained as the average weight of fruits from each plant using a sensitive, digital-type weighing scale. Fruit yield was the sum of all fruits harvested in an experimental unit during the harvest period. The fruit yield was converted to ton/ha.

Weather data

The daily minimum and maximum temperature as well as daily mean relative humidity was measured using a mini-weather station installed about 10 m from the experimental plot. A raingauge, with about 200 cm^2 collecting surface was installed to record rainfall amount while the evaporative demand of the atmosphere was measured at 08:00 h everyday using a small pan evaporimeter. The description of the small pan evaporimeter can be found in Awe et al. (2020).

Statistical analysis

Data collection was subjected to analysis of variance (ANOVA) where F value was significant. Means were separated using Turkey Test at 5% level of significance. All statistics were done in SPSS software (IBM v.20).

Results and Discussion

Weather conditions during the growing cycle

The temporal distribution of the daily minimum and maximum temperature, daily mean relative humidity, rainfall and evaporative demand of the atmosphere during the cucumber growing cycle is presented in Fig. 2. The daily minimum temperature ranged between 12 and 24 ^oC (mean = 20 ^oC) while the daily maximum temperature had values between 23 and 49 ^oC (mean = 39 ^oC). The daily mean relative humidity ranged from 32% to 72%, with mean = 47%. The evaporative demand of the atmosphere (ETo) had values between 3 and 11 mm/day, with a total of 412 mm during the growing cycle. The total rainfall amount received during the period was 75.2 mm, indicating the crop water requirement was not met. To make up for the deficit and avoid crop physiological stress, supplemental irrigation (drip irrigation system) of about 400 mm was applied during the growing period. The daily minimum and maximum temperatures as well as daily mean relative humidity showed increasing trend while the ETo decreased during the growing cycle. The daily mean minimum (20 ^oC) and maximum (39 ^oC) temperatures showed that the cucumber crop was grown under the recommended daily minimum and maximum temperatures 18-21 ^oC and 30 ^oC, respectively for tropical regions (Okafor & Yaduma, 2021).

Soil water content

The results of the effect of plastic mulch and organic manure on soil water content (SWC) of the cucumber field measured at the 0 - 10 and 10 - 20 cm layers are shown in Fig. 3. It was found in the experimental result that mulched treatment had higher SWC than unmulched treatment in both 0 - 10 and 10 - 20 cm layers although the difference was significant ($p < 0.05$)

at the early stage of crop development (Fig. 3a). The higher SWC from mulched treatment is attributed to the beneficial effect of the plastic mulch in reducing evaporation. The use of plastic mulch has been reported to conserve soil moisture under different crops (Anikwe et al., 2007; Mahadeen, 2014; Ma et al., 2018; Mkhabela et al., 2019). At the 0 - 10 cm surface layer, organic manure had no significant effect ($p > 0.05$) on SWC although poultry manure appeared having the highest SWC during the initial stage of crop growth while at later crop growth stages, piggery manure appeared having the highest SWC but did not differ significantly ($p > 0.05$) from Po and control. At the 10 - 20 cm subsurface layer, organic manure significantly ($p < 0.05$) influenced SWC at the initial stage of crop growth with the control soil having the lowest SWC compare to both poultry and piggery manure treated soil. At later growth stages, there were no significant differences ($p > 0.05$) in SWC due to organic manure, with the control appeared having the highest SWC (Fig. 3b). Generally, the 10 - 20 cm subsurface layer had higher SWC compared to the 0 - 10 cm surface layer. The higher SWC in organic amended soil could be due to the fact that the organic manure provided organic matter characterized by higher surface area, thus increased water holding capacity of the soil and this is in line with (Liu et al., 2013). However, the results contradicted the findings of Zhang et al. (2014) who found significant effect of farm yard manure on SWC in the 0 - 10 cm surface layer although they found that SWC increased with increasing soil depth.

Soil temperature

The results of the soil temperature measured at morning time (08:00 h) of 0 - 10 cm and 10 - 20 cm soil layers are presented in Fig. 4. At the 0 - 10 cm layer, there were no significant differences ($p > 0.05$) in soil temperature due to plastic mulching except at the 3 WAP, with mulched plots having the higher soil temperature, between 0.13 and 0.87 ^oC, compared to no mulch. In the 10 - 20 cm subsurface layer, there was significant effect ($p < 0.05$) of plastic mulching on soil temperature at 2 WAP and 3 WAP after which there was no significant effect ($p > 0.05$) till the end of the growing period. Soil temperature in mulched treatment was also higher (between 0.31 and 0.78 ^oC) than that of no mulch (Fig. 4a). In both soil layers, mulched soil had lower standard deviation compared to no mulch soil. Organic manure had no significant effect ($p > 0.05$) on soil temperature in both soil layers although the control (no manure) and poultry manure appeared having the highest and lowest soil temperature, respectively, especially in the 0 - 10 cm surface layer (Fig. 4b). For the 12 h soil temperature monitored during the day (Fig. 5), plastic mulch had significant higher ($p < 0.05$) soil temperature compared to no mulch treatment in both 0 - 10 and 10 - 20 cm layers (Fig. 5a). On the other hand organic manure did not significantly influence ($p > 0.05$) the 12 h soil temperature except at 08:00 h in both soil layers (Fig. 5b).

Generally, soil temperature increased with time, reaching maximum at 3:00 pm, and then decreased but the decrease in soil temperature was not as abrupt in the 10 - 20 cm layer as that of 0 - 10 cm surface layer, indicating some degree of stability in the subsurface layer. In all cases, the soil temperature on the 0 - 10 cm surface layer was higher than that of the10 - 20 cm subsurface layer. Singh and Kamal (2012) found that plastic mulch increased the temperature of mulched soil between 2.2 to 3.4 ^oC compared to bare soil under tomato. Black polythene mulch was also found superior for vegetables such as lettuce (Sultana et al., 2011) by increasing soil temperature as black material is a good conductor of heat. Other researchers such as Gheshm and Brown (2020); Kirigiah et al. (2021) found higher soil temperature in black plastic mulch plot compared to no mulch. Ghuman and Lal (1982) stated that plastic mulch may impede ventilation, and result in a higher average soil temperature under the cover. According to Streak et al. (1994), black plastic mulches are more effective in increasing soil temperature due to a greater net radiation under the mulch compared to bare soil. As a result, the soil heat flux is substantially greater under mulch.

Table 1 Some soil physical and chemical properties of the 0 - 30 cm soil layer of the experimental site

Soil chemical properties								
Soil Depth (cm)	pH_{H2O} 1: 2	OM %	TN g/kg	Av.P mg/kg	Ca	Mg (-------Cmol/kg-------)	K	Na
0 - 10	7.14	0.950	0.09	9.8	1.86	0.82	0.24	0.026
10 - 20	7.05	0.365	0.09	9.6	1.96	0.82	0.18	0.04
20 - 30	6.99	0.656	0.26	71.1	3.20	1.20	0.28	0.04

Soil physical properties								
Soil depth, cm	BD (------g/cm^3-----)	Pd	Pt %	K_{sat} cm/h	Sand	Clay (--------%--------)	Silt	Texture -
0 - 10	1.52	2.30	34.0	19.3	62.1	6.7	31.1	SL
10 - 20	1.57	2.40	34.5	17.6	57.8	4.5	37.7	SL
20 - 30	1.84	2.32	20.8	5.1	58.3	4.6	37.1	SL

OM: Organic matter; TN: Total nitrogen; Av.P: Available phosphorus; Ca: Calcium; Mg: Magnesium; K: Potassium; Na: Sodium; BD: Bulk density; Pd: Particle density; Pt: Total porosity; K_{sat}: Saturated hydraulic conductivity: SL: Sandy loam

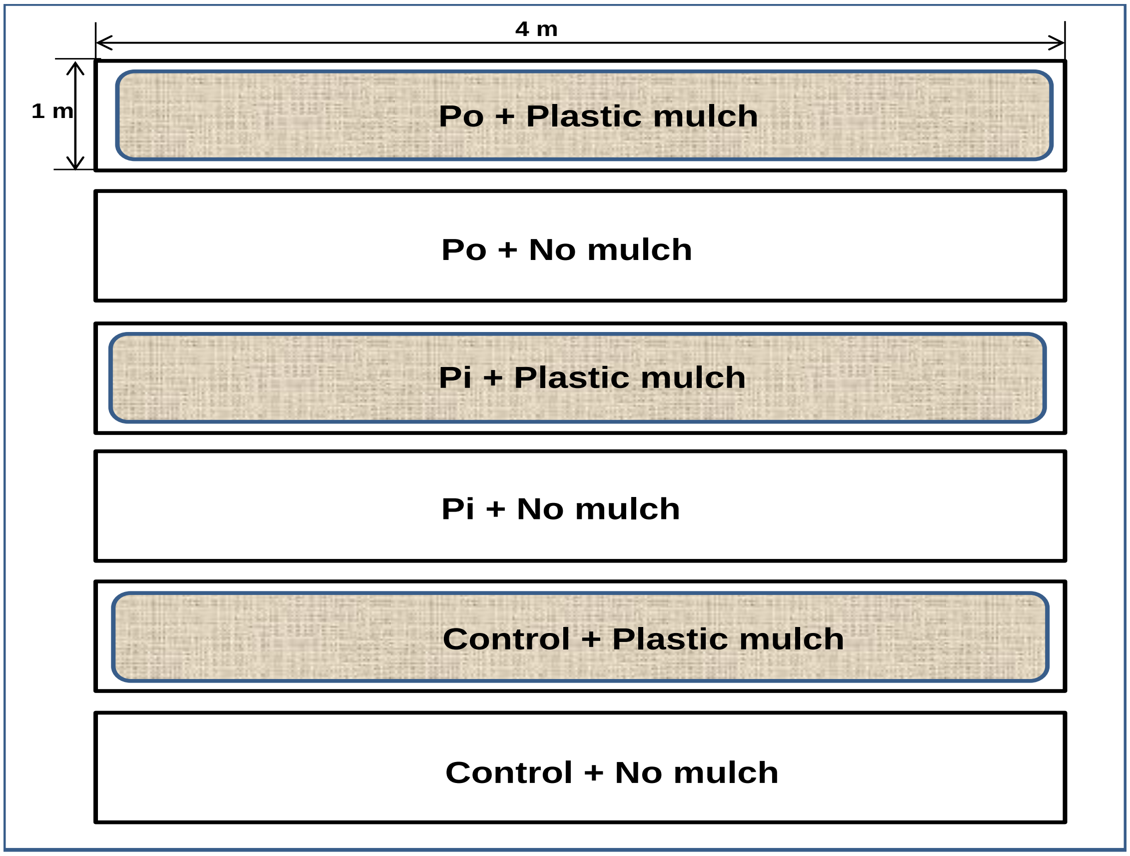

Fig. 1 Field layout showing the treatments in one block of the experimental site Po = Poultry manure; Pi = Piggery manure

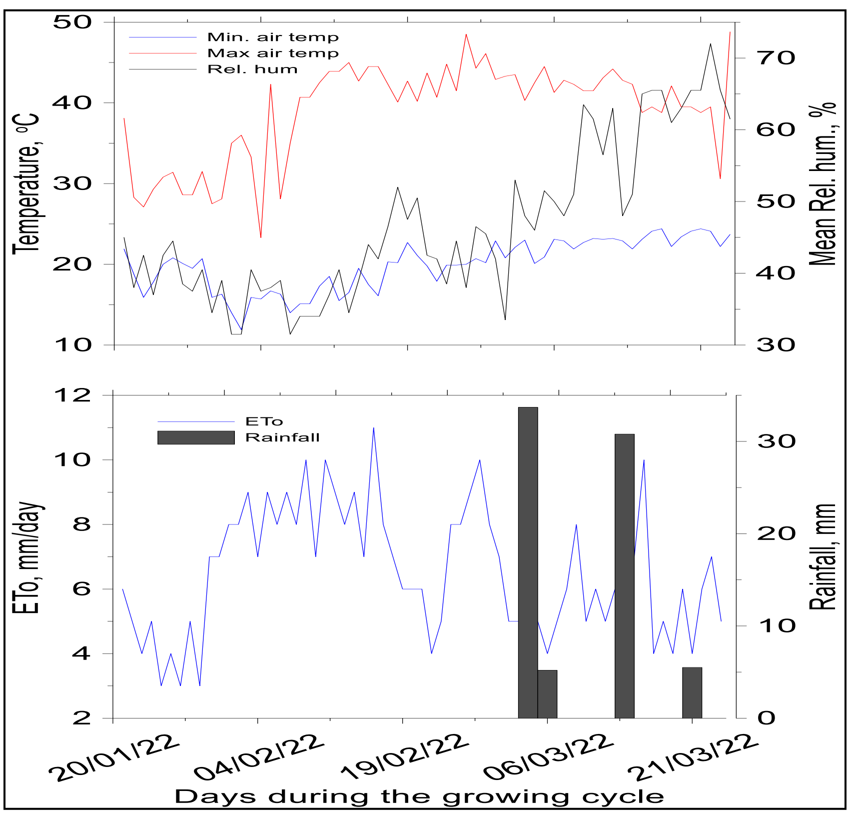

Fig. 2 Daily minimum and maximum temperature, mean relative humidity, Evaporative demand of the atmosphere (ETo) and rainfall during the cucumber growing cycle

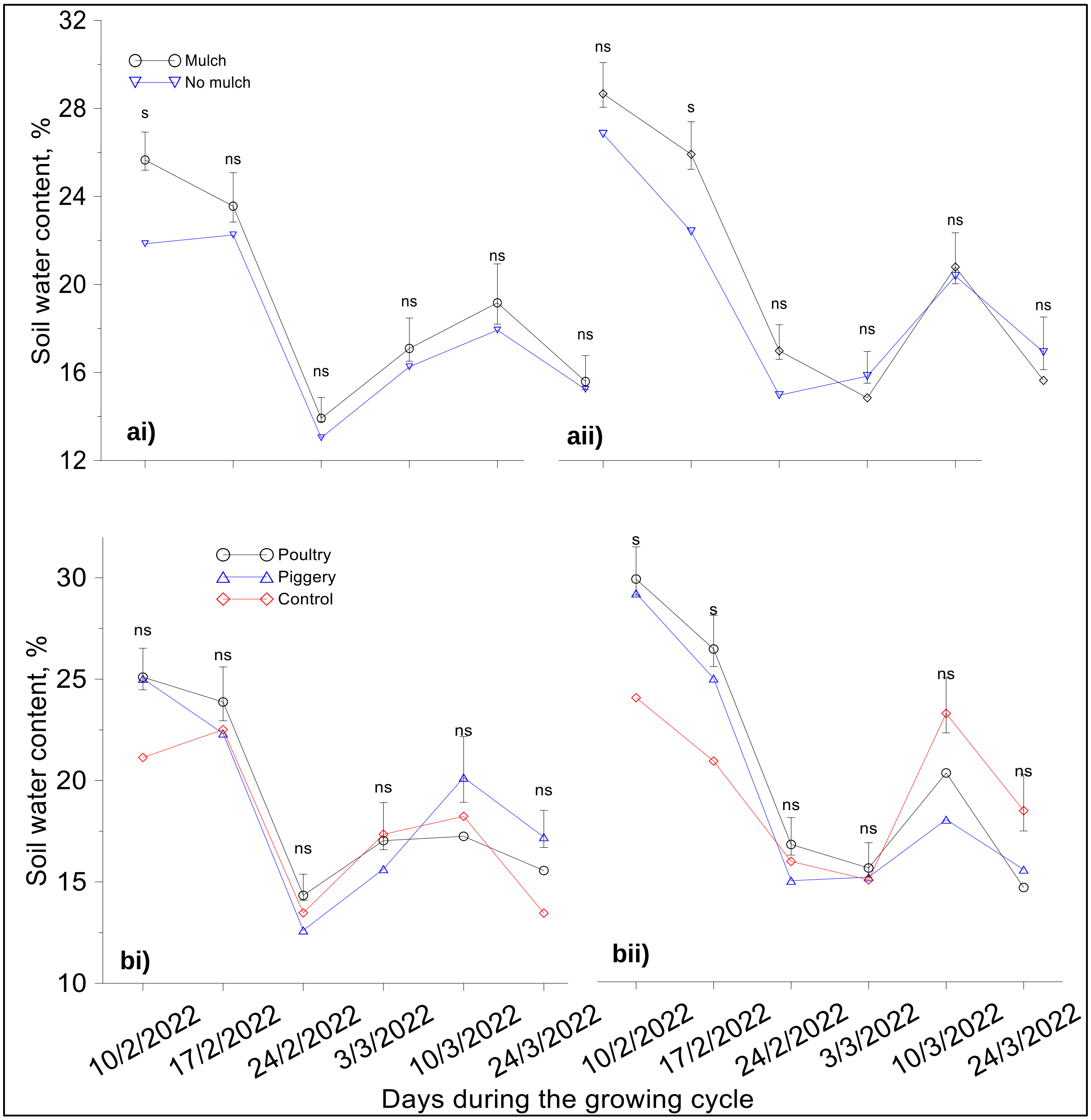

Fig. 3 Effect of (a) plastic mulch and (b) manure on soil water content of the (i) 0 - 10 cm and (ii) 10 - 20 cm layers of the cucumber field. s: Significant, ns: Not significant at 5% level of probability by Tukey test. The capped vertical lines are the standard error of the mean

Growth parameters

The effect of manure, and mulching and their interaction on stem girth, number of leaves, leaf area and vine length are presented in Tables 2 and 3. At 4 WAP, organic manure did not significantly influence ($p > 0.05$) stem girth, vine length and number of leaves while leaf area differed significantly ($p < 0.05$) among the organic manures, with poultry manure having plants with the highest leaf area (about 250 cm^2). Plastic mulch had significantly higher vine length (79.1 cm), number of leaves (24) and leaf area (230 cm^2) than no mulch while the effect on stem girth was not significant with the average value of stem girth at par. At 6 WAP, organic manure had significant effect ($p < 0.05$) on leaf area but not stem girth, vine length and number of leaves, with poultry manure having the highest values of the parameters. The number of leaves and leaf area significantly differed ($p < 0.05$) due to mulching with mulch treatment having higher values compared to no mulch while stem girth and vine length did not differ ($p > 0.05$) due to mulch treatment. At 8 WAP, similar results as for 6WAP were obtained for both mulching and organic manure treatments. The interaction effect of organic manure and mulching was not significant ($p > 0.05$) on the measured growth parameters during the growing period (Tables 2 and 3).

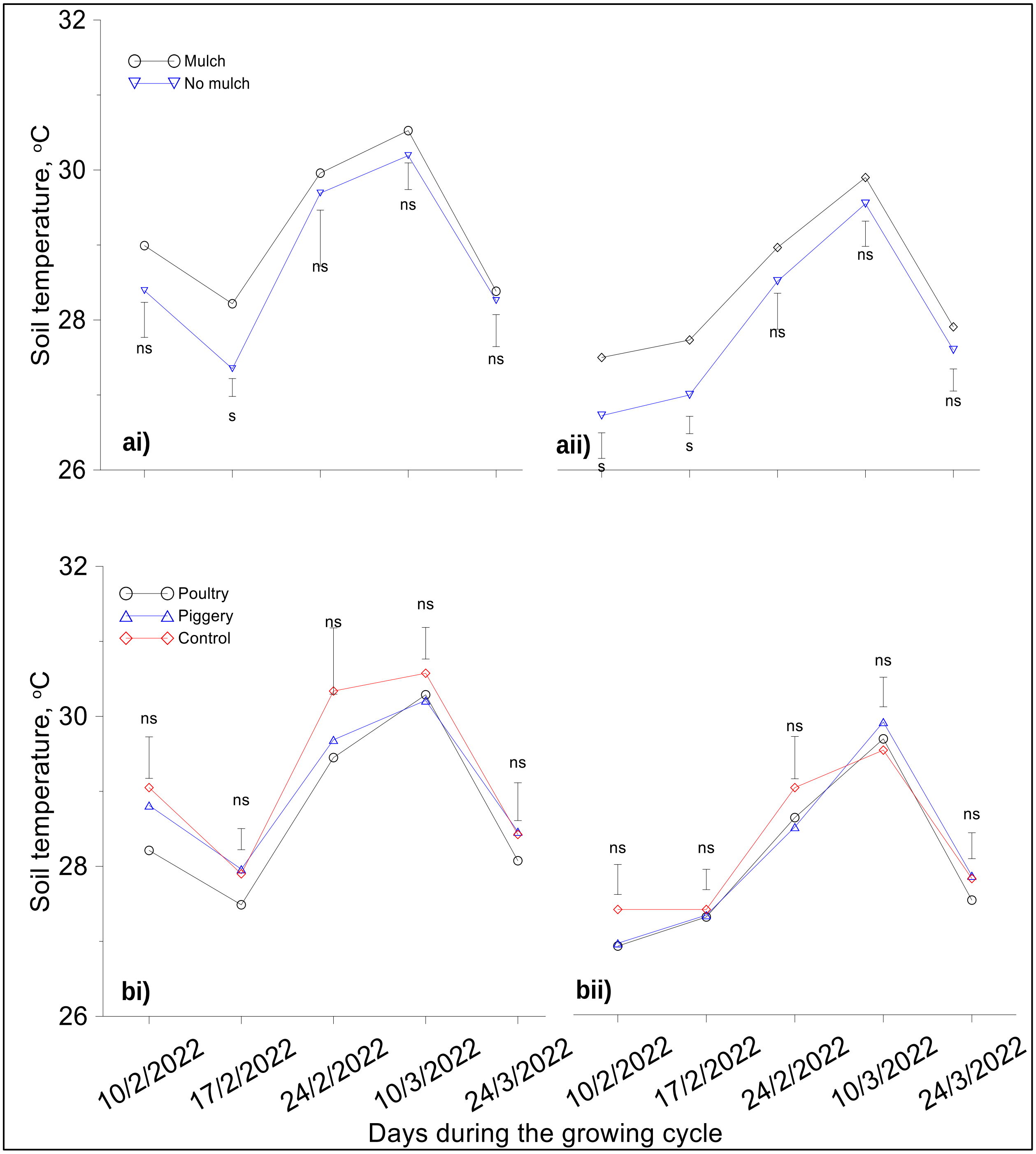

Fig. 4 Effect of (a) plastic mulch and (b) organic manure on soil temperature of the (i) 0 - 10 cm and (ii) 10 - 20 cm layers of the cucumber field. s: significant, ns: not significant at 5% level of probability by Tukey test. Vertical bars are the standard error of the mean.

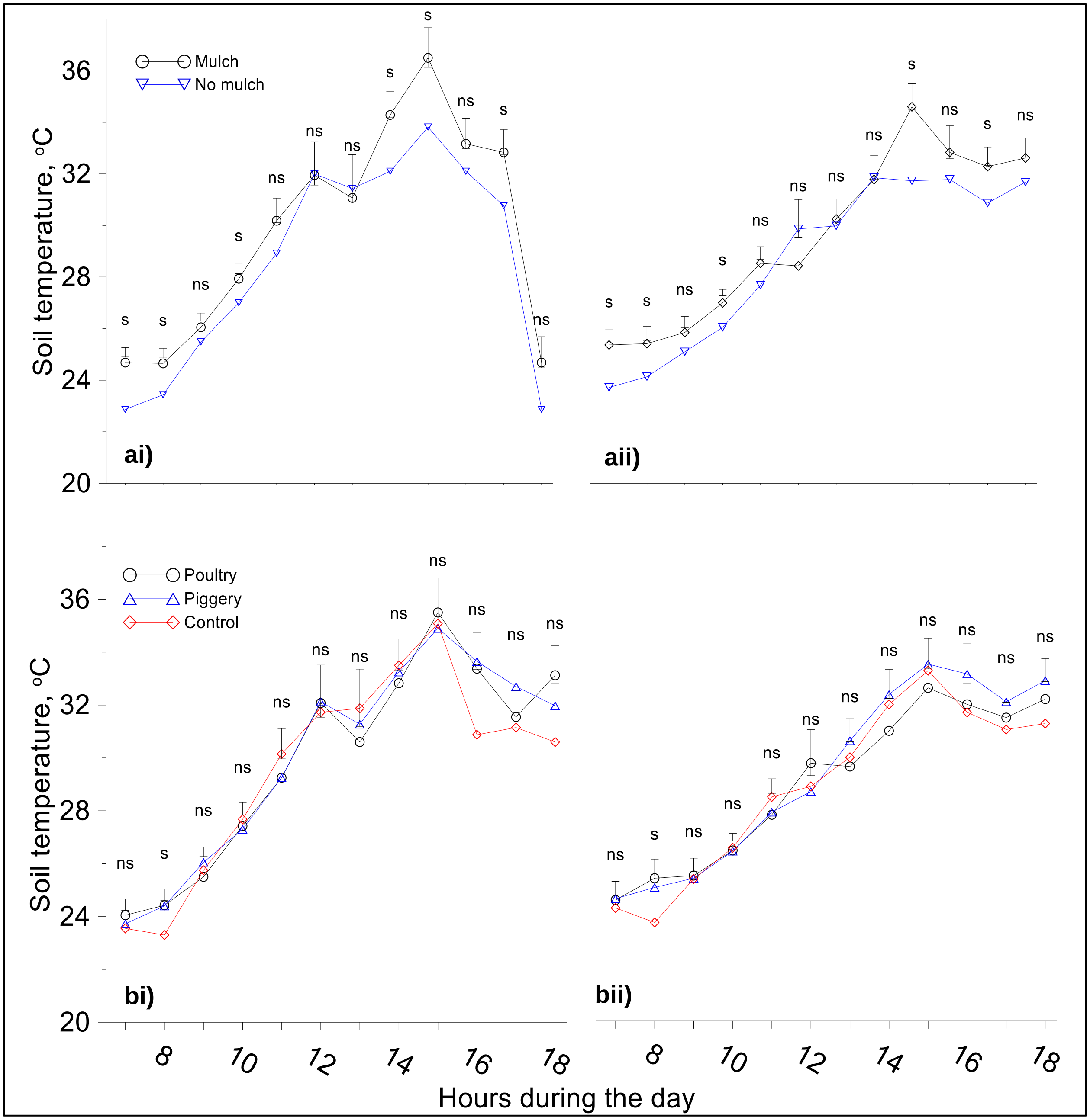

Fig. 5 Diurnal variation of soil temperature of the (i) 0 - 10 cm and (ii) 10 - 20 cm layers of the cucumber field under (a) plastic mulch and (b) manure treatments. s: Significant, ns: Not significant at 5% level of probability by Tukey test. Vertical bars are the standard error of the mean

Yield, yield components and water use efficiency

The results of the effect of manure, mulching and their interaction on yield components and water use efficiency (WUE) of the cucumber are presented in Table 4. The number of fruits differed significantly ($p < 0.05$) due to organic manure, with poultry manure having the highest (22) number of fruits while the control (no manure) had the lowest value (12). Fruit length, fruit diameter, yield and WUE did not differ significantly ($p > 0.05$) due to organic manure treatment although poultry manure treatment had the highest values of the parameters. Mulching significantly affected ($p < 0.05$) the number of fruits of cucumber with mulch treatment having the higher value (22) compared to no mulch (13). Similarly, fruit length, fruit diameter, yield and WUE did not differ significantly ($p > 0.05$) due to mulching but the yield and WUE were higher in mulched plots compared to no mulch. The interaction effect between organic manure and mulching was not significant ($p > 0.05$) on the yield components and WUE nevertheless the treatment combination of poultry manure and plastic mulch gave the highest number of fruits, yield and WUE. The result obtained for poultry manure application was similar to the findings of Agu et al. (2015) who reported significant increase in cucumber plant growth parameters under various mulching conditions which provides better yield compared to plant grown without mulch. Across all mulches, black polythene mulch produced the highest early yield and yield per plant (Soleymani et al., 2015). Adinde et al. (2021) reported that poultry manure significantly ($p < 0.05$) gave higher vine length, number of branches per plant, number of leaves per plant, leaf area index, number of fruits per plant, fruit yield per plant and fruit yield per hectare compared to control. The higher yield from mulched treatment is also linked with higher soil temperature, soil water availability, and reduced competition with weeds (Singh et al., 2005; Mehta et al., 2010).

Table 2 Effect of manure, mulching and their interaction on stem girth (SG, cm) and vine length (VL, cm) of the cucumber

		SG	VL	SG	VL	SG	VL
Manure		4 WAP		6 WAP		8 WAP	
	Poultry	6.7	81.4	13.9	157.1	16.9	160.4
	Piggery	5.4	67.1	13.7	137.0	15.8	140.4
	Control	5.5	59.5	11.3	118.5	12.1	120.3
	SEM	0.4	6.9	1.1	10.8	1.3	10.8
	Sig	0.05	0.11	0.21	0.07	0.06	0.05
Mulch							
	Mulch	5.9	79.1	14.0	143.3	16.4	146.9
	No mulch	5.9	59.6	11.9	131.8	13.5	133.8
	SEM	0.3	5.6	0.9	8.9	1.1	8.8
	Sig	0.99	0.03	0.11	0.38	0.08	0.31
Manure × Mulch							
Poultry	Mulch	6.8	92.0	15.7	151.5	20.5	155.8
	No mulch	6.7	70.8	12.1	162.8	13.3	165.0
Piggery	Mulch	5.3	73.8	14.0	148.8	15.7	153.3
	No mulch	5.4	60.5	13.4	125.3	15.9	127.5
Control	Mulch	5.5	71.5	12.4	129.5	13.0	131.8
	No mulch	5.5	47.5	10.3	107.5	11.2	108.8
	SEM	0.6	9.7	1.5	15.3	1.9	15.3
	Sig	0.98	0.85	0.63	0.46	0.16	0.46

WAP: weeks after planting; SEM: standard error of the mean; Sig: significant level at 5% level of probability

Table 3 Effect of manure, mulching and their interaction on number of leaves (NOL) and leaf area (LA, cm^2) of the cucumber

		NOL	LA	NOL	LA	NOL	LA
Manure		4 WAP		6 WAP		8 WAP	
	Poultry	22	249.7	39	287.7	44	334.6
	Piggery	18	196.4	33	221.1	38	254.4
	Control	16	163.7	31	178.4	37	243.3
	SEM	2.2	19.5	2.7	20.0	2.4	13.2
	Sig	0.16	0.02	0.17	0.01	0.13	0.00
Mulch							
	Mulch	24	230.4	40	264.6	45.4	306.4
	No mulch	14	176.1	29	193.6	33.2	248.5
	SEM	1.8	15.9	2.2	16.3	2.0	10.8
	Sig	0.001	0.03	0.00	0.01	0.001	0.002
Manure × Mulch							
Poultry	Mulch	28	283.2	42	337.4	49.0	383.1
	No mulch	16	216.3	33	238.0	38.0	286.0
Piggery	Mulch	22	206.0	38	235.5	43.3	276.4
	No mulch	114	186.7	28	206.7	32.5	232.5
Control	Mulch	20	202.1	38	220.9	44.0	259.6
	No mulch	12	125.3	24	135.9	29.0	227.1
	SEM	3.1	27.6	3.8	28.3	3.4	18.6
	Sig	0.84	0.55	0.79	0.44	0.79	0.21

WAP: weeks after planting; SEM: standard error of the mean; Sig: significant level at 5% level of probability by Tukey test

Table 4 Effect of manure, mulching and their interaction on yield and water use efficiency of the cucumber

Manure		NoFrt -	FrtLngth cm	FrtDia cm	Yield kg/m^2	WUE kg/m²/mm
	Poultry	22a	53.0	29.0	3.39	0.032
	Piggery	18ab	53.5	27.5	1.84	0.017
	Control	12b	51.1	29.2	1.16	0.011
	SEM	2.33	1.49	1.95	0.80	0.007
	Sig	0.03	0.51	0.79	0.18	0.18
Mulch						
	Mulch	22a	52.9	28.1	2.936	0.027
	No mulch	13b	52.2	29.0	1.324	0.012
	SEM	1.90	1.22	1.59	0.65	0.006
	Sig	0.01	0.68	0.70	0.11	0.11
Manure × Mulch						
Poultry	Mulch	27	52.8	28.4	5.02	0.047
	No mulch	17	53.2	29.7	1.75	0.016
Piggery	Mulch	23	52.4	28.1	2.33	0.022
	No mulch	14	54.6	26.9	1.36	0.013
Control	Mulch	15	53.5	27.9	1.46	0.014
	No mulch	9	48.8	30.5	0.86	0.008
	SEM	3.30	2.11	2.76	1.13	0.011
	Sig	0.79	0.28	0.78	0.46	0.46

NoFrt: number of fruits; FrtLngth: fruit length; FrtDia: fruit diameter; WUE: water use efficiency; SEM: standard error of the mean; Sig: significant level at 5% level of probability by Tukey test

Conclusion and Recommendation

Plastic mulching and poultry manure increased the soil water content. While plastic mulching increased the soil temperature, it was reduced by poultry manure application. Cucumber grown with poultry manure had the best growth parameters, yield components and water use efficiency compared to piggery manure and the control. Mulching enhanced the cucumber growth parameters, yield components and water use efficiency compared to no mulch. The results showed that planting of cucumber using poultry manure and plastic mulch was superior on the parameters tested. It is recommended that farmers in the study area could combine poultry manure with plastic mulch for better soil conditions and increased growth and yield of cucumber and similar vegetables in the region.

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