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The Effect of Colored Plastic Covers on Transpiration Rate of Water

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Abstract

Water hyacinth (Echhornia crassipes) is one of the invasive and is considered as one of the most notorious aquatic weeds because of its fast spread and crowded growth. Manual removal of the plant is considered to be the most environmentally friendly way of controlling the plant but it is laborious when the plant covers large area. Field experiment study was conducted on water hyacinth plants collected from Ziway Lake to estimate the effect of colored plastic covers on the transpiration rates of the plant. In addition, crop factors (Kc) and coefficients of evaporation (Cp) of the covered plants were also compared with the uncovered plants. Transpiration losses were determined from the difference in the volume of water from the pan containing the treatment and control plants and the volume of water lost from the pan evaporation. The water losses from the pans were calculated from the differences in the depths of water in the pans before and after the successive measurement days. For this, calibration was done to correlate the depth of water level (in the pan) to the volume of water lost by evapotranspiration. Besides, water loss measurements, pictures were also taken for visual observation of the plants at every level during the experiment. Data analysis was made using Microsoft Office Excel. Comparisons were made using one-way ANOVA followed by pair comparisons Evapotranspiration estimation for Zeway area was done using the modified and optimized Temesgen-Melesse's method. The result showed that the mean ET of the uncovered plant, those covered by Black plastic (Bpc) and transparent plastic covered (Tpc) plants were 2.25L/d (7.96mm/d), 0.26L/d (0.92 mm/d) and 0.35L/d (1.24mm/d), respectively, compared to the mean daily pan evaporation of 0.88 L/d (3.11 mm/d). The transpiration rate from the control plants was 1.37L/d (4.85 mm/d), but those covered by Tp and Bp did not show any transpiration. Additionally, the Cp calculated showed 1.09, 0.40 and 0.30 for the control, Tpc and Bpc plants, respectively. The Kc result showed 1.42, 0.22, and 0.16 for the control, Tpc and Bpc plants, respectively. ANOVA results of T, Cp showed significant differences between treatments and the control but no differences within treatments. Out of the two, the transparent plastic cover showed superior performance in adversely affecting the performance of the plant and in terms of its endurance in resisting the external environment. This study showed promising result in killing the plant so that it would be easy to remove the plant from the water body. However, we recommend the study to be conducted in the real environment of the plant (on lakes, or dams infested with water hyacinth).

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1. Introduction

Lakes and reservoirs sometimes harbor floating aquatic plants that cover the water body. When covering the water body, the aquatic plants act as shades and reduce direct evaporation. However, they also remove substantial amount of water from the water body in the form of transpiration. Water hyacinth (*Eichhornia crassipes*) is one of such aquatic plants. Water hyacinth is considered as one of the most notorious aquatic weeds and is ranked among the top ten world's worst weeds. It is a noxious weed that has attracted worldwide attention due to its fast spread and crowded growth, which leads to serious problems in navigation, irrigation, and power generation. It is also renowned as a non-native, invasive and free-floating aquatic macrophyte that has abundant and uncontrolled growth in open pond and other water bodies (Gopal, 1987). The weed has the ability to create anoxic conditions on lakes, thereby increasing the level of toxicity and disease (Güereña et al., 2015), blocks water canals (Ndimele et al., 2011), interferes with lake navigation (Tumbare, 2008), and enhances mosquito population (Priya and Selvan, 2017; Sindhu et al., 2017), threats to the functioning and biodiversity of aquatic ecosystems fisheries (Attermeyer et al., 2016), interferences in irrigation systems (Opande *et al.*, 2004), increases sedimentation (Bordoloi et al., 2015) and leads to increased water loss through evapotranspiration (ET) relative to normal open water evaporation (Villamagna and Murphy, 2010; Arp et al., 2017). A major lake like Lake Victoria of Kenya, which is the largest freshwater body in the tropics, has undergone serious ecological changes including invasion by water hyacinth during the 1990s even though the condition is currently improving.(Katerga and Sterner, 2007; Peninah et al., 2013). The weed has also infested other lakes such as Lake Tana and Lake Zeway from the neighboring country.

The rapid increase and spread of the plant into new areas is due to its vegetative reproduction, which means a single plant is able to grow very rapidly and cause a significant infestation. The other challenge is the fact that it can move easily with water currents, winds or other accidental means, such as fishing nets and boats. Due to these bthe plant invades rivers, canals, ponds, lakes, dams and other freshwater bodies. Different mechanisms such as biological, chemical and physical methods have been tried to control the plant. The biological control makes use of insects and fungal pathogens (DiTomaso et al., 2013). It requires high cost and has long time lag that can take 20 years or more (McFadyen, 2000). The chemical system mostly involves growth inhibitors (DiTomaso et al., 2013). The use of chemicals results in eutrophication and also causes dissolved oxygen depletion. In short, it causes ecological problem besides involving high cost and being unsustainable (Labrada, 1995; Elenwo and Akankals, 2019).

The physical system makes use of mechanical methods such as using machineries, confinement boom or fences and manual removal. The choices of methods depend on the level of infestation, resources available and the use of the waterway (NSW Department of Primary industries, 2013). When the level of infestation is very large, the control requires harvesting equipment such as mechanical choppers and shredders. Such machineries leave behind fragments that can re-establish. There are also possibilities of dispersing of weeds by moving water or with winds (DiTomaso et al., 2013). Moreover, the use of aquatic machineries for large infestation is costly besides, damages the aquatic ecosystem. Manual removal is suitable during early stages of development of the plant, when the infested area is small and if the plants are scattered. In this case, the removed plants have to be buried or dried out to decompose and limit the spread of seed. The manual method, though expensive and laborious is beneficial since the water can be used immediately following the control, especially when the water bodies are used for irrigation and for stock and human consumption. The floating boom (made from nets or rope) and containment fences are usually used to limit the infestation area and to minimize cost and time required for physical removal, to separate area that requires different treatment and to allow staged removal (NSW Department of Primary Industries, 2013).

The hydrological impact of water hyacinth is its high transpiration rates. The increased transpiration due to the dense mates of water hyacinth can have serious implications where water is limited for human needs, for fish, birds and other organisms (Noble, 1991). Open water evaporation generally depends on several factors such as solar radiation intensity, relative humidity, wind speed, etc. but on average it is 3 mm/d for most aquatic plants while ET is on average of 7.8 mm/d (Stan *et al.,* 2016). In the absence of vegetation, the water volume lost by evaporation is lower than with aquatic plants' transpiration (Angela *et al*., 2014). In the case of water hyacinth, water loss can reach three times greater than the natural evaporation rate of water surface that does not have water hyacinth (Osmond and Petroeschhevsky, 2013). Immersed and floating plants, such as cattail and water hyacinth, because of their structure and leaf area transpire more water than the water that would evaporate from the same area of water body. Therefore lakes filled with immersed and floating plants will lose more water to the atmosphere than lakes having fewer plants (Maguerite and Rawlik, 1993).

Reddy and Sutton (1984) in their study of water hyacinth in Aba Samuel wetland, Ethiopia reported that under normal condition, loosely packed water hyacinth of relatively low plant density (10 kg/m^2 wet mass) can reach maximum density of 50 Kg/m^2 and can cover the water surface in a short time. Therefore increased water loss through ET of water hyacinth and its rapid increase and spread is considered one of the most crucial problems in water bodies. Hence, estimating water losses through ET by aquatic weeds is very important to know the impact of the weed on the livelihood of the water body (Florentina et al., 2016).

Even though the emergence of water hyacinth in Ethiopia has been over five decades, the weed has become a menace in recent years. This seems to be due to the extensive use of fertilizers, which ultimately joins water bodies by flood and causes eutrophication. Finding ways of water losses from water hyacinth is not only important also a necessity to increase the existence of lakes and reservoirs. So far an attempt done to achieve this goal is by removing the plant from the water body. Nevertheless, this is cumbersome, time consuming, and requires the use of mechanical devices or substantial manpower. The experience on Lake Tana has shown how challenging it was to use manpower after the plant has widely spread. Since there are also other lakes that have very large infestation of this plant, some way of reducing the manual labor is imperative. Decreasing the transpiration rate from this plant is also necessary. This study was aimed to achieve two things. In the first case assumption was made that the use of plastic cover minimizes transpiration rate since the transpired water condenses on the plastic and returns to the waterbody. The second point is putting the plant under heat stress that could possibly kill or wilt the plant. A dead plant or wilted plant weighs less and it becomes easy to remove the dead or wilted plant from the water body very easily. No or limited studies were done to fight water hyacinth by such method. . This study is therefore attempting to find a way to minimize the aggressiveness of the weed by manipulating the amount of radiation and wind that gets into the plant. The study tries to find an alternative way of addressing this problem by using physical ways (using plastic cover) to put the plant under heat stress.

2. Materials and methods

2.1. The Study area

This research was carried out around Zeway Lake, Ethiopia. The water hyacinth used in the experiment was collected from Zeway Lake. The geographical coordinate of the experimental site is 7.935°N latitude, 38.928°E longitude and its mean elevation above sea level is 1640 m. The mean annual maximum and minimum temperatures of the area are 13.3°C and 29.4°C, respectively (Mengistu and Amente, 2019). The experiment was conducted adjacent to the Lake that is located close to Zeway town shown in Fig. 1.

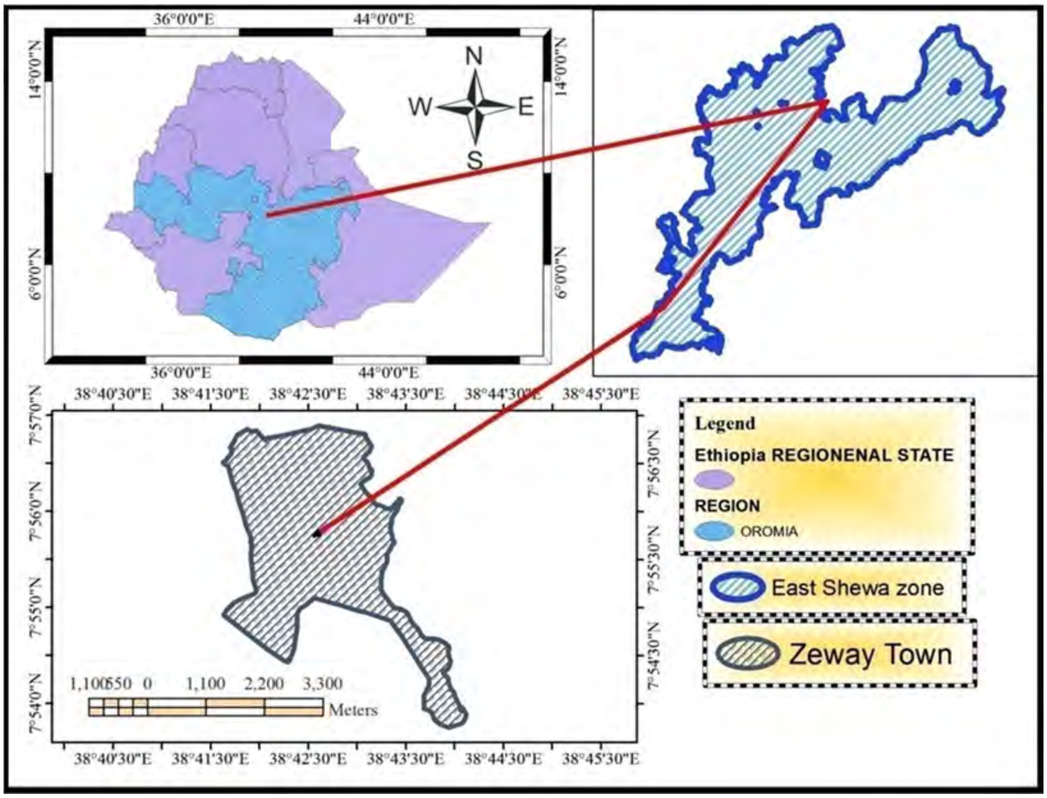


Figure 1:- Map of Zeway town

2.2. Experimental Materials

The materials used in this experiment were, 12 evaporation pans with depths of 16 cm and inner diameter of 60 cm each, twelve 60 cm x 60 cm x 10 cm wooden bases to serve as seats for the pans, digital balance used to measure the mass of water hyacinth, thermometer to measure temperature during measurement, Styrofoam, meter stick to measure depth of water from the top, two liter capacity plastic container, lake water, transparent plastic and black plastic, camera to take pictures of the plants during measurement time and scissors to cut the plastics. Wire mesh and wooden posts were used to fence the study area.

2.3. Experimental Setup

In this experimental work, the experiment site was selected since all the experimental units get full sunlight throughout the day. The site selected was free from shades and bushes. Safety of the equipment and the researchers were also taken into consideration when selecting the site. The experimental area was cleaned to make it suitable for the experiment. The area was fenced by mesh wire to protect the area of the experiment. Then the ground was leveled and checked by spirit level to make sure that the water level in the pan stays horizontal. Then wooden bases were prepared and placed on the leveled surface to avoid the inclination of the level of water in the pans. The weight of each pan was measured and recorded prior to adding anything to the pan and each pan was labeled and its weight was marked on the outer surface. The pans were placed on the wooden bases. To each pan equal volumes of lake water (22 liters) were added to about three-fourth of the size of the pan.

Water hyacinths were collected from the lake; their masses were measured using digital balance and equal weights (2.5 kg on average) were carefully placed in the nine of the twelve pans without overcrowding but just enough to cover the water surface in the pan. The treatments and control plants were prepared in three replications each thereby making a total of nine experimental units. Three of the pans were covered with transparent plastic, another three of them covered with black plastic, and the remaining three were left uncovered (control group). In addition, three pans were also used to measure plain water pan evaporation of the area. The experimental setup is shown in Fig. 2.

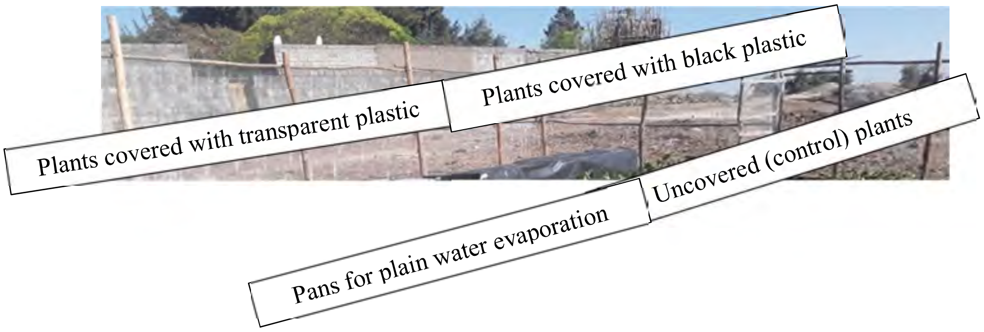


Figure 2:- Arrangements of the experimental units

Temporary homemade rain gauge was also installed to measure the amount of rainfall just in case rainfall happens during the test period. This was to calculate the amount of water added to each pan because of the rain.

2.4. Data Collection

The volume of water lost by ET was measured indirectly from the depth of water level drop in the pan (Adeloye, 2019). This was because of the difficulty of getting accurate balance that is capable of measuring the mass of the pan with plants and water, at the site. The depths of the water levels from the top of the pan were measured by placing the meter stick horizontally on the pan and by measuring the distance from the meter stick to the water surface as shown in Fig. 3. In order to convert the depth difference to the volume of water lost by ET calibration was done prior to the experiment. Calibration was done by measuring the depth (*d*) against the volume of water (*V*). After every 2 L was added, a stiff wire connected to a Styrofoam was inserted into the pan and allowed to reach the water surface. Then the distance from the base of the Styrofoam to the horizontal meter stick was measured accurately (shown as d_1 and d_2 in the figure). Every time a given volume of water was added the depth slightly reduced from d_1 to d_2. The depth difference was then correlated to the volume of water added. After the water level reached the required depth, plot of *d* measured (in mm) versus *V (L)* was done and the plot was curve fitted with the best equation that adequately described the curve. The equation was used every time depth to volume conversion was required. This method was used to get the amount of water lost by ET and E from each pan.

Transpiration was obtained from the difference of the mean ET of the replicated treatments/control and the mean pan evaporation of the plain water. In this study, data was gathered for over a period of seventeen days. Measurements were taken every third day during the first 9 days and every other day during the remaining time. The time gap changed since there were substantial water losses by evaporation that necessitated reduction of the time gap.

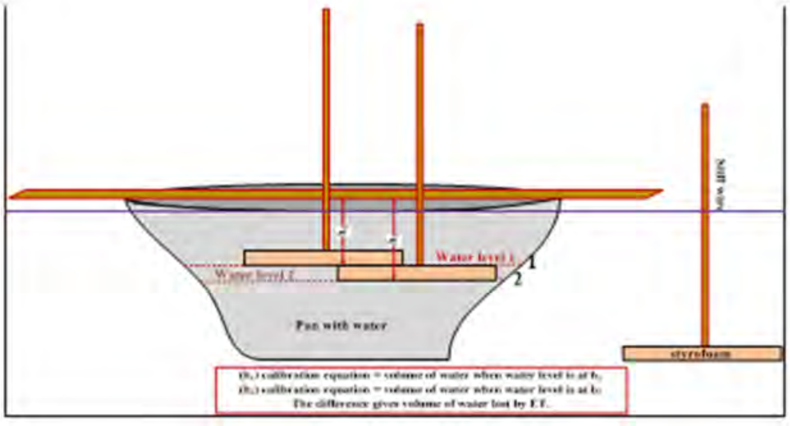


Figure 3:- Estimation of ET by water volume change method.

During each measurement, pictures of the plant samples were also taken and the day and sample number were recorded. The pictures were for qualitative observations of the condition of the plants, especially the changes of plants with black and transparent plastic covers. Secondary data that satisfy the potential evapotranspiration of the area were obtained from Hawasa, Ethiopia meteorological station. At the end of the experiment, the weights of the plants of each experimental unit were measured and recorded. In addition, the volume and the weight of water that remained in the pan were also measured and recorded. The difference between the original weight of the plant and its final weight (averaged for the three replications) were used to find the weight the plant gained/lost over the duration of the experiment.

2.5. Mathematical Methods used for Data Analyses

In this study the treatments and the control were compared using three parameters. The first is the rate of transpiration, which was obtained by subtracting average pan evaporation (E) from the treatment/control average evapotranspiration (ET). The second parameter was the crop factor (C_p) or evaporation coefficient. It is the ratio of plant ET and free water (pan) evaporation.

$$C_p = \frac{ET}{E} \ldots\ldots\ldots\ldots\ldots..(1)$$

It is a unitless quantity so long as the same units are used in both cases. It measures how much water the plant loses by ET compared to plain water evaporation. The third quantity is crop coefficient (K_c), which is the ratio of mean ET (of the 17 days) of the plant to that of potential evapotranspiration (ET_o) of the area. ET from a crop surface is calculated as a function of K_c, the crop coefficient derived for a particular plant species, and ET_o, a reference ET value that characterizes the evaporative demand of the region. The K_c is the crop coefficient for a given crop and is usually determined experimentally. Its values represent the integrated effects of changes in leaf area, plant height, crop characteristics, irrigation method, rate of crop development, crop planting date, degree of canopy cover, canopy resistance, soil and climate conditions, and management practices. Each crop will have a set of specific crop coefficient and will predict different water use for different crops for different growth stages.

Factors affecting the value of the crop coefficient (K_c) are mainly the crop characteristics, rate of crop development, length of growing season and climatic conditions. By using the FAO Penman-Monteith definition for ET_o, crop coefficients can be calculated at research sites by relating the measured crop ET with the calculated ET_o (Rashed, 2014). The K_c factor serves as an aggregation of the physical and physiological differences between crops and the reference definition.

In order to calculate K_c it is necessary to convert the measured ET is in *L/d* to *mm/d* for unit compatibility.

$$K_c = \frac{ET}{ET_o} \ldots\ldots\ldots\ldots\ldots \quad (2)$$

For this, the liter is converted to *mm/d* after which the quantity is divided by the top surface area of the pan. That means,

$$ET_{mm} = \frac{ET_L \times 10^6}{\pi\left(\frac{D}{2}\right)^2} \ldots\ldots\ldots. (3)$$

In the equation D = is the diameter of the pan, ET_L= is the measured ET in liters, and ET_{mm}= is the same ET in mm. The diameter of the pan is 60 cm (= 600 mm) and therefore

$$ET_{mm} = \frac{ET_L \times 10^6}{\pi(300)^2} = \frac{ET_L \times 10^6}{282600}$$
$$= 3.5386ET_L \ldots\ldots\ldots. (4).$$

Thereafter it is possible to use Eq. 2 to find K_c as

$$K_c = \frac{ET_{mm}}{ET_o} = \frac{3.539\, ET_L}{5.60\, mm}$$
$$= \frac{3.54\, ET_L}{5.60\, mm} \ldots\ldots\ldots. (5)$$

The next step is obtaining the potential evapotranspiration (ET_o) of the area. It is evapotranspiration rate from a reference surface, not short of water and therefore it is called the reference crop ET or reference ET. The reference surface is a hypothetical grass reference crop with specific characteristics. The only factors affecting ET_o are climatic parameters. Consequently, ET_o is a climatic parameter and can be computed from weather data. ET_o expresses the evaporating power of the atmosphere at a specific location and time of the year and does not consider the crop characteristics and soil factors (Hou *et al.,* 2010; Berti *et al.,* 2014; Valipour, 2015; Zhao *et al.,* 2015).

The energy required for ET is mainly available from direct solar radiation and to a lesser extent, the ambient temperature of air (Allen *et al.,* 1998). The driving force to remove water from the evaporating surface depends on the difference between water vapor pressure of the evaporating surface and that of the surrounding atmosphere (Bosen, 1960). Furthermore, wind speed significantly affects the movement of vapor flow in the air. Hence, solar radiation, air temperature, air humidity and wind speed are the main meteorological parameters to consider when assessing the ET_o processes (Morton, 1994; Xu and Singh, 1998).

In order to estimate ET_o, the use of the Penman equation would have been appropriate (Allen, *et al.,* 1998). However, since the meteorological data obtained from Hawassa lacked sunshine hour, an alternative approach of using the modified and optimized Temesgen Melesse's equation (Mengistu and Amente, 2020) was used. The equation makes use of mean maximum temperature of the location, daily maximum temperatures during the study period, latitude and altitude of the study area. The equation is of the form

$$ET_o = \frac{\bar{T}_{mx}{}^{n_{opt}}}{48Tmx - 330} \ldots\ldots\ldots\ldots\ldots. (6)$$

The optimized *n* value (n_{opt}) and the $\bar{T}_{mx}$ values of Zeway were obtained from Mengistu and Amente (2020) calculations. The optimized *n* (n_{opt}) for Ziway station made use of latitude, 7.56°N, altitude, 1640 m, 30-year average maximum temperature of Ziway, 26.86°C, and the result of n_{opt} obtained is 2.494.

The data obtained were organized using Microsoft Excel and analyzed in accordance with the specific parameter of interest. Comparison of ET of the treatments and the control were made using Microsoft excel. Comparisons of transpiration rates of the treatments and the control and C_p values were made using one-way ANOVA. Comparisons of K_c values were done graphically.

3. Results and Discussion

3.1. Transpiration Rates of the Treatments and the Control

3.1.1. Measured pan evaporation

Evaporation was measured using pan evaporation method with three replications. In order to find daily evaporation, first the total evaporation from each pan over seventeen days is obtained. Next the average of the three pans was calculated and the result was divided by seventeen to find the daily evaporation value. In order to find the volume of water evaporated, first the depth data were converted into volume of water using the calibration equation. Table 1 shows the pan evaporation rates calculated from water level depth.

Table 1:- Pan Evaporation rates tabulated with the Mean, standard deviation and coefficient of variation.

Gap (d)	R1, E (L/d)	R2, E(L/d)	R3, E (L/d)	Mean E(L/d)	SD	CV
3	2.38	2.63	2.29	2.43	0.18	0.07
3	1.53	1.44	1.70	1.56	0.13	0.08
3	1.87	2.12	1.95	1.98	0.13	0.07
2	2.42	2.80	2.04	2.42	0.38	0.16
2	2.17	1.91	2.17	2.08	0.15	0.07
2	2.55	2.55	2.42	2.50	0.07	0.03
2	2.04	2.29	1.53	1.95	0.39	0.20
Total evaporation over 17 days (L)				14.93		
Daily mean evaporation (L)				0.88		

R1, R2, and R3 represent replications, SD = standard deviation, CV = coefficient of variation. The gap indicates the number of days between two consecutive readings.

As observed in the above table, daily mean E over the 17 days is 0.88 L/d and this when converted to mm/d using Eq. (4) gives 3.11 mm/d. This result is close to the average evaporation of 3.0 mm d^{-1} (Stan *et al.,* 2016).

3.1.2. Transpiration Values of the Control Group

The transpiration rate of the control group was calculated by subtracting the pan E value from the ET. The calculated values along with the ratio of the transpiration to E are shown in Table 2.

Table 2: Transpiration of the control group shown with the daily mean and the ratio, T/E

Gap (d)	Mean control ET (L/d)	Pan E (L/d)	Control T (L/d)	T/E
3	6.14	2.43	3.71	1.5
3	6.45	1.56	4.90	3.1
3	5.60	1.98	3.62	1.8
2	4.25	2.42	1.83	0.8
2	5.18	2.08	3.10	1.5
2	5.56	2.50	3.06	1.2
2	5.05	1.95	3.10	1.6
Total	38.24	14.93	23.31	11.55
Daily mean	2.25	0.88	1.37	0.68
T/E				1.56

The transpiration rates are obtained from the difference between the ET of the control group and the pure water E measured by pan measurement method. The daily mean transpiration of the plant is 1.37 L/d, which comes to 4.85 mm/d using the conversion Eq. (4). This value is greater than the pan E by a factor of 1.56 (= 1.37/0.88) and it indicates that the plant transpires more water than free water evaporation. The daily mean ET of the control is 2.25 L /d (7.96 mm d^{-1}).

In the control group, the water hyacinth plant covers large area of the surface of the pan that limits the amount of solar radiation that reaches the water surface below the plant. Thus the plant has a 'shading effect' that reduces the amount of evaporation from the water underneath the plant. Therefore the larger fraction of the ET comes from transpiration and this undermined the *T/E* value.

The daily ET from water hyacinth obtained in this study was 7.96 mm d^{-1}. Daniel (2009) on the other hand, used the method of leaf area index and obtained water loss of 18.57 mm and 12.33 mmd^{-1} during dry and wet seasons, respectively, in his research on water surface covered by water hyacinth in Aba Samuel wetland, Ethiopia,. This value is still higher than what was obtained in this study and the difference could be due to the methods used for the determination of ET.

The ratio of T/E 4.7 obtained by Johansson (1977) is about three times than what we obtained (1.56). Johansson did his test when the maximum temperature was very high (36°C) and daytime relative humidity was lower (35%) as compared to ours, which was 31°C and 50%, respectively. This difference must have contributed to the differences between his T/E value and ours. Johansson also covered the pan with plastic to reduce evaporation, but such coverage increases transpiration because of the heat introduced due to the greenhouse effect.

3.1.4. Transpiration Rates of the Treatment Groups.

In this part the mean transpiration rates of the treatment with black plastic cover and transparent plastic cover are shown together (Table 3).

Table 3: Transpiration rates of plants under black plastic (Bpc) and transparent plastic (Tpc) covers.

Gap (d)	Bpc ET(L/d)	Pan E (L/d)	Bpc T (L/d)	Tpc ET(L/d)	Tpc T (L/d)
3	1.33	2.43	-1.10	1.61	-0.82
3	0.23	1.56	-1.33	0.51	-1.05
3	0.74	1.98	-1.24	0.54	-1.44
2	0.55	2.42	-1.87	0.89	-1.53
2	0.38	2.08	-1.70	0.68	-1.40
2	0.76	2.51	-1.75	1.06	-1.45
2	0.47	1.95	-1.48	0.68	-1.27
Total	4.46	14.93	-10.47	5.97	-8.96
Daily mean	0.26	0.88	-0.62	0.35	-0.53
T/E			-0.70		-0.60

As it has seen in Table 3, the daily transpiration rates of the plastic covered plants in both cases showed negative results, which means there were no transpirations from the plants and in addition, the negative values indicate that the cover has reduced the rate of evaporation. The reduction in the rate of evaporation could be seen in two ways. The first is due to the shading effect of the plastic that reduces the inside temperature and thereby reduces the evaporation rate (Kadlec, 1989).

The second and perhaps the more plausible argument is the return of a portion of the evaporated water back into the pan as a result of condensation, especially when the temperature drops (during nighttime). This is particularly true in the case of the transparent plastic cover, since in this case, the inside temperature increases during the daytime due to greenhouse effect during which evaporation was definitely eminent. In this regard, both covers have done good jobs of reducing the rate of ET even below the free water evaporation.

Looking at the two treatments and the control together reveals how transpiration exceeds the pan evaporation for the control plant and the nonexistence of transpiration from the plastic covered plants (Fig. 4).

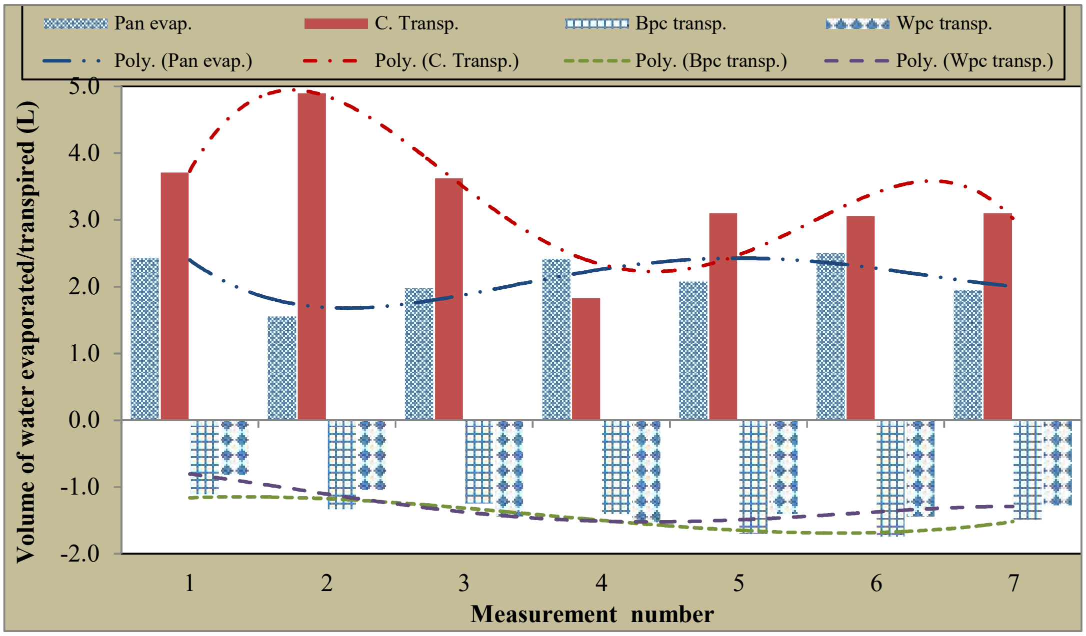


Figure 4: Comparisons of transpiration rates of the plastic covered plants and the control plant with free water evaporation.

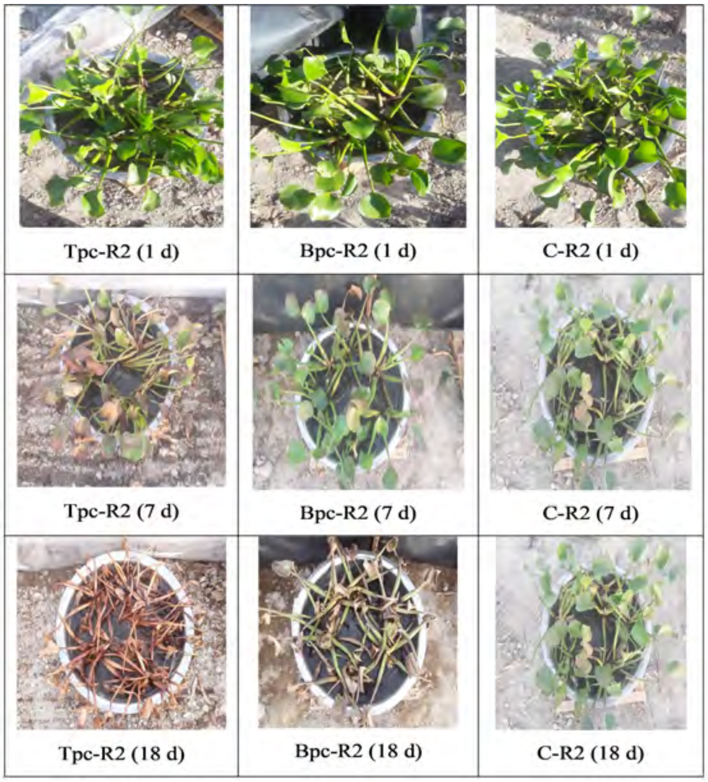
As it has seen in the figure, during every measurement, the volume of water transpired by the treatment groups were all negative. The treatments exhibited almost linear reduction in transpiration up to the fifthe measurement. Statistical comparison among the treatments and the control is shown in Table 4.

Table 4:- One-way ANOVA to show difference between the treatments and the control.

Source	df	SS	MS	F	Fc	Significance
Treatment	2	102.48	51.24	157.92	3.55	S*
Error	18	5.84	0.32			
Total	20	108.32				

The table shows significant difference at p = 0.05 level. Fc is critical F value at 0.05 for treatment MS degree of freedom (df) of 2 and error MS df of 18.

Table 4 shows statistically significant differences at 0.05 levels. Pair comparisons show significant differences between the control and plants with Bpc, the control and plants with Tpc, but not between Bpc and Tpc. The fact that there is no difference between the two treatments indicates that both types of plastics could be used if the aim is to reduce transpiration rate. However, from what was observed during the experiment, the transparent plastic is more preferable. The reason is that the plants under the transparent plastic first wilted and finally died after a couple of days (Fig. 5), whereas those under Bpc did not show the same result.



Tpc-R2 (1 d)
Bpc-R2 (1 d)
C-R2 (1 d)
Tpc-R2 (7 d)
Bpc-R2 (7 d)
C-R2 (7 d)
Tpc-R2 (18 d)
Bpc-R2 (18 d)
C-R2 (18 d)

Figure 5: Pictures of one of the three replications shown for the two treatments and the control. Tpc = transparent plastic cover, Bpc = Black plastic cover, C = control (uncovered plant) and R stands for replication.

The pictures were taken every measurement day but the ones shown here are the pictures taken at the beginning (1st d), on the 7th (7 d), and on the last day (18 d). The plant with the transparent plastic cover (Tpc) wilted on the 12th day and completely died at the end of the experiment. The one with the black plastic cover (Bpc) showed wilting only at the end of the experiment. Transparent plastic cover absorbs little but transmits 85% to 95% of the incoming shortwave radiation. The water that condenses under the surface of clear plastic cover is also transparent to the incoming shortwave radiation but is opaque to outgoing long wave infrared radiation. As a result, much of the heat is retained by the clear plastic cover (Coleman, 1995). Black plastic cover is an opaque black-body absorber and radiator. The black cover absorbs most UV, visible, and infrared wavelengths of incoming solar radiation and re-radiates absorbed energy in the form of thermal radiation or long wavelength infrared radiation both upward to the atmosphere and downward to the plant. The heat absorbed by the plant can put the plant under heat stress. Despite that, it seems that the plant under the black plastic cover managed to tolerate the heat better than the one under the transparent plastic cover. The difference indicates that the greenhouse effect under the transparent cover is more aggressive in putting the plant under heat stress than the thermal radiation from the black cover. The picture also shows that the pan environment is not as suitable as the lake since even the control plant showed slight change even if it did lack neither water nor radiation.

The second reason why the transparent plastic is preferred is because of its endurance to withstand radiation. The black plastic deteriorated and was torn after about a week and it had to be replaced. The reason could be the high radiation absorption rate of the black plastic or it could be due to the quality of the plastic material itself.

Under the lake environment, it will be necessary to remove both the wilted and even the dried plant from the water surface since it is unsightly and in addition because it adds organic matter into the lake that may increase eutrophication and also nitrogen content of the lake. Reducing the levels nitrogen and phosphorous in the water will reduce the growth of water hyacinth or any other aquatic plant (DiTomaso et al., 2013).

3.2. Calculated Evaporation Coefficients (Crop Factor, Cp)

The crop factor for the plant is the ratio of plant ET and free water evaporation (Eq. 1). Based on this equation, the value of C_p for the normal plant (control) was found to be 2.56.

$$C_p = \frac{Mean\ ET}{Mean\ E} = \frac{2.25}{0.88} = 2.56.$$

This value is close to the results obtained earlier by other researchers. For example, Maguerite and Rawlik (1993) found a value ranging from 3 to 6 for water hyacinth plants. Our value is close to the low end of Maguerite and Rawlik's results. Johansson (1977) did a 48 h test in Tanzania and found ET equivalent of 25.6 mm d^{-1}. He also determined the free water evaporation of the area to be 5.476 mm d^{-1}. This indicates his C_p value comes to 4.67. This is also slightly higher than what is obtained in our study. The difference could be attributed to the weather condition in which he did his experiment (maximum temperature of 36°C, minimum 20°C, and relative humidity varied between *35%* during the day and *55%* at night). Daniel (2009) in his work on water hyacinth in Aba Samuel wetland, Ethiopia found 18.57 mm and 12.33 mm of water lost per day in dry and wet seasons, respectively. The value he obtained during dry season is higher than ours.

The value of C_p for the plant covered by black plastic is found to be 0.30.

$$C_{p(Bpc)} = \frac{Mean\ ET.Bpc}{Mean\ E} = \frac{0.26}{0.88} = 0.30.$$

The value of C_p for the plant covered by transparent plastic is 0.40.

$$C_{p(Tpc)} = \frac{Mean\ ET.Tpc}{Mean\ E} = \frac{0.35}{0.88} = 0.40.$$

The two values are close to each other. However, the fact that the C_p values of the treatments are less than one indicates the absence of transpiration and the reduction of free water evaporation from their respective pans. This is understandable because of the plastic cover that increases condensation even though not all of the condensed water returns to the pan. A portion of the water drops to the ground since the plastic cover is not covering the pans alone but also the spaces between the pans. The summarized result is shown in Table 5.

Table 5:- Crop factor (C_p) values of the two treatments (Bpc and Tpc) and the control (C).

Measurement day	Control C_p	Bpc C_p	Tpc C_p
3	2.52	0.55	0.66
6	4.14	0.15	0.33
9	2.82	0.37	0.27
11	1.75	0.23	0.37
13	2.49	0.18	0.33
15	2.22	0.31	0.42
17	2.55	0.24	0.35
Total	18.50	2.03	2.73
Daily mean	1.09	0.12	0.16
(C_{pt}/C_{pc})%		11.01	14.67

C_{pt} represents C_p of the treatment group (Bpc C_p or Tpc C_p) and C_{pc} represents C_p of the control plant.

As seen in Table 5, the ratios of the crop factors of the two treatments with respect to the control are nearly 11% and 15% for black plastic covered and transparent plastic covered water hyacinth plants, respectively. But in order to see whether there is significant difference or not comparisons are made using one-way ANOVA and the result is shown in Table 6.

Table 6:- One-way ANOVA to show differences of Cp values between the treatments and the control.

Source	df	SS	MS	F	Fc	Significance
Treatment	2	24.64	12.32	63.02	3.55	S*
Error	18	3.52	0.20			
Total	20	28.16				

The ANOVA table shows significant difference among the three at $p = 0.05$ level. The pair comparisons show significant differences between the control and those plants with Bpc, the control and plants with Tpc, but not between Bpc and Tpc. Thus, as far as statistical comparisons are concerned the two plastics work well in significantly reducing the rates of transpiration.

4.3. Calculation of Crop Coefficient (K_c)

Crop coefficient is the ratio of plant ET and the potential ET (ET_o) of the area. For unit compatibility ET conversion from liters per day to mm/d was done using Eq. (4). Next ET_o was obtained from Eq. (6) and the calculated ET_o is shown in Table 7.

Table 7:- Estimation of ET by Mengistu and Amente (2020) method.

T_{mx} (°C)	Mean T_{mx}	ET_o (mm/d)
29.8	26.86	4.88
30.2	26.86	5.05
31.8	26.86	5.74
32.0	26.86	5.83
32.4	26.86	6.02
31.8	26.86	5.74
30.8	26.86	5.30
28.8	26.86	4.49
31.6	26.86	5.65
31.2	26.86	5.48
31.4	26.86	5.56
32.2	26.86	5.92
31.8	26.86	5.74
31.4	26.86	5.56
32.0	26.86	5.83
31.8	26.86	5.74
32.8	26.86	6.20
32.4	26.86	6.02
Mean ET		5.60
SD		0.43

From the table, the mean ET_o is 5.60 mm/d and the K_c calculated using Eq. (3) for the treatments and the control are shown in Table 8.

Table 8:- Crop coefficient values of the two treatments and the control.

	ET(L/d)	ET (mm/d)	ET_o (mm)	K_c
C	2.25	7.96	5.6	1.41
Bpc	0.26	0.92	5.6	0.16
TPc	0.35	1.24	5.6	0.22

The K_c values are substantially lower for the two treatments compared to the control. The control K_c is by over nine and six times greater than those of black plastic covered and transparent plastic covered plants, respectively. It means the treatment K_c values are almost nonexistent. The very low K_c values indicate the insignificance of the treatment ET compared to the potential ET of the area. The lower values of K_c in the case of plants with black plastic cover indicate more shading (reduced solar radiation reaching the water surface underneath the plant) than those of transparent plastic covered plants. According to Kadlec (1989), the presence of vegetation retards evaporation from the water surface. This is understandable since the leaves of the transparent plastic covered plants showed less shading effect since they started wilting earlier than those of black plastic covered plants. The result of ET/ET_o of 1.41 obtained for the uncovered (control) plant in our case is almost identical to the value of 1.44 obtained by Van der Weert and Kamerling (1974**)** in their well-controlled experiment in Surinam in 1968.

4. Conclusion and Implications

This study was conducted to compute and compare the ET and transpiration rates of water hyacinth plants collected from Ziway Lake in which the treatment plants were covered by black and transparent plastic and the control plants were uncovered. As observed from the results, ET of plants with black plastic cover exhibited 12% ET and the plants with transparent plastic cover 16% of the total ET of the control groups, respectively. Both treatments did not show any transpiration and therefore both transparent and black plastic covers work well as far as transpiration reduction is concerned. C_p values were 11% and 15% of the normal plant for the plants with Bpc and Tpc, respectively. K_c values of Bpc and Tpc plants were almost nonexistent (almost zero) compared to that of the normal plant. As far as the test results are concerned, the effects of color plastic cover on the water hyacinth were more beneficial in reducing the transpiration rates from water hyacinth plants. Transparent plastic cover is more efficient in killing the plant. Putiing the plant under thermal stress is doing a nice job of killing or damaging the plants and that makes removal of the plant from the water bodies easier.

Conflict of Interests

The authors declare that there's no conflict of interest concerning to the publication of this article.

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