Water and Petrol Use Efficiencies of Cabbages and Kales Under Supplemental Irrigation in Kimumu Farm in Uasin Gishu County, Kenya

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American Journal of Agricultural Science Engineering and Technology

ISSN: 2158-8104 (Online), 2164-0920 (Print)

Volume: 4, Issue: 3

Published by: e-Palli,
Florida, USA

The American Journal of Agricultural Science, Engineering and Technology (AJASET) is blind peer reviewed international journal publishing articles that emphasize research, development and application within the fields of agricultural science, engineering and technology. The AJASET covers all areas of Agricultural Science, Engineering and Technology, publishing original research articles. The AJASET reviews article within approximately two weeks of submission and publishes accepted articles online immediately upon receiving the final versions.

Published Media: ISSN: 2158-8104 (Online), 2164-0920 (Print).

Frequency: 4 issues per year (January, April, July, October)

Area of publication: Agricultural Science, Engineering and Technology. The subjects covered by the journal includes but not limited to:

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WATER AND PETROL USE EFFICIENCIES OF CABBAGES AND KALES UNDER SUPPLEMENTAL IRRIGATION IN KIMUMU FARM IN UASIN GISHU COUNTY, KENYA

Clement Kiprotich Kiptum[1*] and Jane Wangoi Ndungu[2]

ABSTRACT

Cabbages and Kales grown in Kimumu Scheme in Uasin Gishu County were monitored between November, 2017 and February, 2018 for a period of 90 days. Water was pumped from ponds to the vegetables after transplanting. The amount of petrol, rainfall and water applied together with the yields were measured. The water stress for cabbages during the entire period was 91%. During the head formation stage, the water stress 81%. For kales the water stress started from day 53 to day 90 except for days 55, 60, and 64 after transplanting. The water stress for kales during the entire period was 97%. From mid- season stage, the water stress was 88%. The yield of cabbages and kales were 4.25 tons/ha and 11.8 tons/ha, respectively. The water use efficiencies were 1.4 Kg/ m^3 and 3.8 Kg/ m^3 for cabbages and kales, respectively. The petrol use efficiencies were 7727 Kg/ m^3 and 23 529 Kg/ m^3 for cabbages and kales, respectively. The water use efficiency for kales was approximately three times that of cabbages while the petrol efficiency was also around three times. Since kales are more tolerant to water stress, the farmer was advised to grow kales as they perform better in both water and petrol use efficiencies.

Keywords: Water stress, use efficiency, growth stage and yields.

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BACKGROUND

Cabbages together with kales are the main vegetables in Kenya. The average cabbage crop production in Kenya is 28 tons/ha and requires 250 kg/ha of Double Ammonium Phosphate (DAP) when planting and top dressing using Calcium Ammonium Nitrate(CAN) at a rate of 250 Kg/ha (MOA Handbook, 2012). Kales average production is 13 tons/ha and requires 250 Kg/ and 200 Kg/ha of DAP and CAN, respectively.

The productions of cabbages and kales as it is with other crops vary with the amount of rainfall. When the amount of rainfall is little or none and no irrigation, the production of cabbages and kales is affected negatively because cabbage crop water requirement is not met. Water needed to meet for normal growth, development and yield supplied through rainfall, irrigation or both is known as water requirement (Sinha *et al*., 1985).

Water use efficiency here means the harvestable yield divided by the volume of water applied to the vegetables either through irrigation or rainfall. Petrol use efficiency is the quotient of yield and the volume of applied petrol.

There are several ways of applying water to fields in Kenya. They include drip, sprinkler, pump and pipe and bucket and hand irrigation. The uses of traditional methods of irrigation have persisted despite the new advancement in the field of irrigation. This shows that peasant farmers do not readily accept new methods and there is need to gradually introduce them to new procedures by first examining what they use and how they can be assisted.

Some of the cabbage hybrid varieties grown in Kenya include; Baraka F1 that matures after 75 days, Blue Dynasty F1 that matures after 80-85 days, CPI that matures after 70-80 days, Globe Master F1 that matures after 75 days, Gloria F1 that matures after 90 days, and Riana F1 that matures after 90-100 days (Seif and Nyambo, 2013). Kale-Thousand head yielding 8 tons/ha and collard Southern Georgia that yields 6 tons/ha are some of the varieties of Kales grown in Kenya. They both require 60 days to mature (Royal seed Full seed catalogue, 2018). In Kimumu farm, collard Southern Georgia was grown because its stem does not rot like that of Thousand headed based on farmer’s experience. Cabbages have the following growth stages according to (Allen *et al*., 1998): *Initial stage* from transplanting starts from day 1 to day 20 after transplanting and has 7-9 leaves. *Development stage* also known as cupping or folding and occurs between days 21-50 after transplanting. *Mid season stage* is where the head is 50-100 mm early head formation from days 51-80. *Late season* is where the head is around 200 mm in diameter and occurs from day 80 to day 90 after transplanting. During the head formation stage, cabbage is more sensitive to water stress (Adeniran *et al*., 2010). Kales also have initial, development, mid season and late season as kales. Kales reach maturity at 60 days.

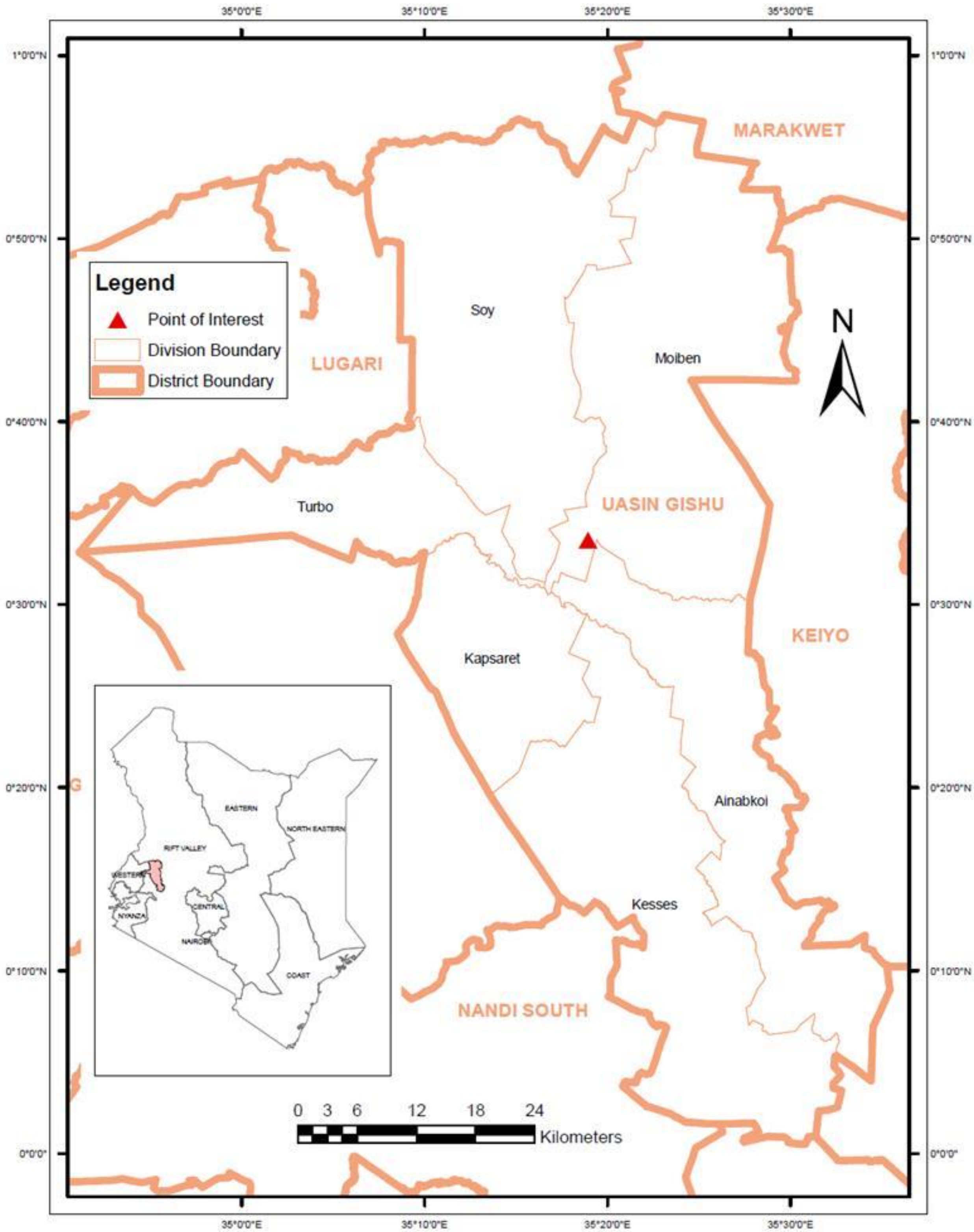
Growing of cabbages and kales during dry season is normally affected by pests. The main pests that attack cabbages are cut worms and aphids. Cabbage and kale aphids look like other aphids but with a greyish waxy coat similar to wood ash. Some plants may be stunted and unmarketable because of pests (Bessin, 2011).

Many studies have been of experimental nature and very few or none have been done to monitor the growing of vegetables during the dry season in Uasin Gishu. Experimental plots make sure that the vegetables are controlled and shielded from many challenges. By monitoring a farmers irrigation schedule, it is easy to appreciate the challenges farmers face which are absent in the experimental plots.

The purpose of the study was to determine through monitoring the water and petrol use efficiencies of cabbages and kales with a view of assisting farmers to know which crop to plant during the dry season. A farm was monitored during the dry season 2017-2018 in Uasin Gishu County. The results pointed out challenges farmers face during the dry season which if addressed by the government can help in improving food security in the country.

METHODOLOGY

The study area was a farmer's farm in Kimumu scheme in Moiben Sub-County of Uasin Gishu County in Kenya as shown in Figure 1 as point of interest. The study was done between 22nd November, 2017 and 22nd , February 2018. The plot was at an altitude 2145 metres above sea level and lies between Longitudes 35^o 18'54.84 and 35^o 18'54.84 E and Latitudes 0^o 33'32.59 and 0^o 33'32.65 N. The farmer's land was trapezoidal in shape. The parallel sides had lengths of 4 m and 5.5 m while the height was 34 m giving an area of 160 m^2. Kales were grown on 34 m^2 of land adjacent to the cabbage plot.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Moiben
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UASIN GISHU
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Cabbages branded Gloria F1 and Kales Collard Southern Georgia were transplanted on 22nd November, 2017. The vegetables had 2-3 leaves when they were being transplanted. The ground was wetted before transplanting. Four kilograms of Di-ammonium phosphate (DAP) was applied during transplanting. Four Kilograms of Calcium Ammonium Nitrate were applied 19 days after transplanting. The vegetables were irrigated as per the farmer's guidelines. 65 millimetres of Duduthrin were mixed in 20 litres of water and was applied on 20, 26, 33, 40, 51 and 80 days after transplanting to control aphids and other crop pests like cut worms.

Water requirement was found by multiplying the crop coefficients for cabbages and Kales (Figure 2) by the reference crop evapotranspiration (Allen *et al.*, 1998) . Both cabbages and kales have initial crop coefficient K_c of 0.7 with the highest coefficient of 1.05 and 0.95 for cabbages and kales, respectively. Cabbages coefficient decreases in the late season stage while that of kales remains the same for mid-season and late season stages.

Growth stages of kales and cabbages are similar except that for cabbages harvest is done once at the end of 90 days while that of kales harvesting was done thrice until the end of 90 days. Harvesting of kales was extended to 90 days for good utilization of land.

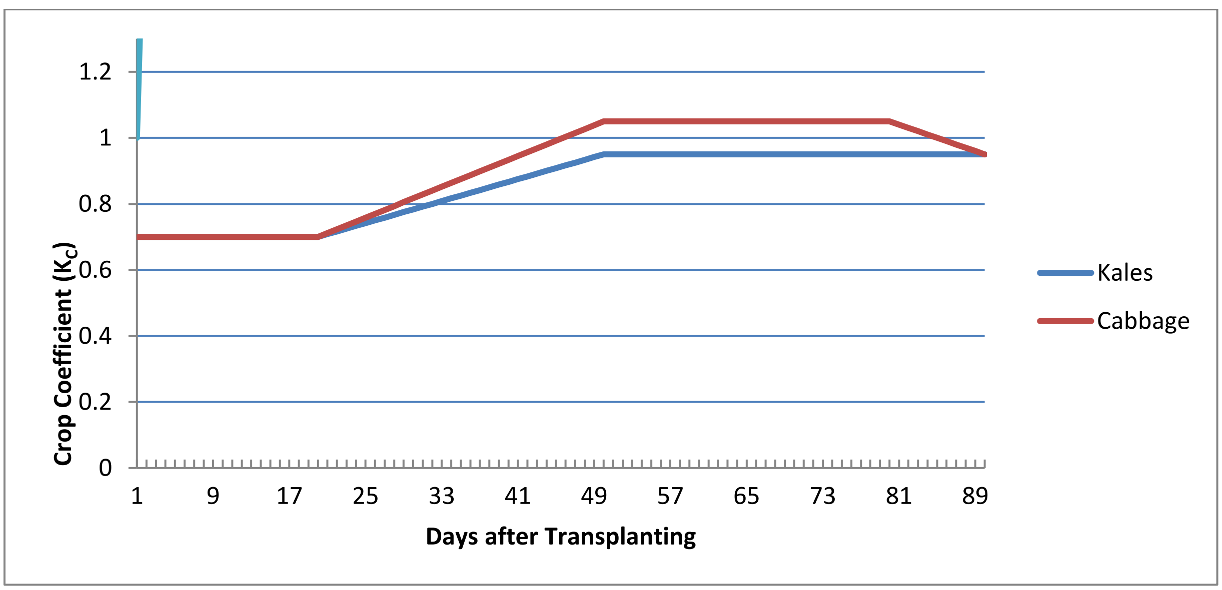

Figure 2: Crop coefficients for Cabbages and Kales

The supplemental irrigation of cabbages and kales in Kimumu scheme in Uasin Gishu County was done by pumping water from a pond to irrigate cabbages. Supplemental irrigation was done to augment the rainfall during the dry season in Uasin Gishu which normally occurs between the months of November and February of every year. The pond had a diameter of 3 m and a depth of 1.2 m which gave a total volume of 8.5 m^3. The pump used petrol to pump 1litre/second of water.

Amount of water pumped from the pond was determined by measuring the depth of water used (the difference between the initial depth before pumping and the final depth measured after pumping) and multiplying by the area of pond. The amount of water applied on the farm in millimetres was calculated by dividing the amount of water by the area of the field. When the pond dried the water was obtained from another pond which had no regular shape. Therefore, measuring of water used was done by pumping water into a 10 litre container and noting the time it took to fill the container. During irrigation the time it took to irrigate the entire field was recorded and multiplied by the discharge rate to get amount of water consumed.

When it rained the farmer the farmer skipped irrigation by 1 day when rainfall observed was less than 5mm, skipped 2 days when the rainfall amount was between 5 and 10 mm and skipped a week when rainfall was in excess of 17 mm.

Percent water stress was calculated by dividing the amount of water consumed by total crop water requirement for the specific growth stage or the entire 90 days and multiplying by one hundred.

Petrol consumed by machine during the day of pumping was done by measuring the inside dimensions of the fuel tank. In noting the start and finish depths of petrol in the machine after irrigation the volume of petrol used was determined. The depths were measured using a wooden ruler as it was easy to note the depths since petrol wets timber ruler.

The number of seedlings that survived after being transplanted were recorded. The yield of cabbages and kales were measured after 90 days and 60 days, respectively using a spring balance with minimum graduations of 0.5 kg.

RESULTS AND DISCUSSION

IRRIGATION OF THE VEGETABLES

Supplemental irrigation was done to augment the rainfall. A total of 60.8 mm of the rainfall was observed during the growing period of Nov.2017 and February, 2018. The rainfall contributed 20% of the applied water in Table 1. A graph was plotted to compare the water requirements and the amount of water supplied to the crop either by irrigation or rainfall and presented in Figure 2. From day 1 to day 50 after transplanting, the applied water was more than the crop requirements for both cabbage and kales.

From Figure 3, the water was not applied for a period of seven days between days 44 to 50 after transplanting. The long period of no irrigation was because the farmer assumed that the rainfall of 17.3 mm that rained on day 43 after transplanting was still in the soil.

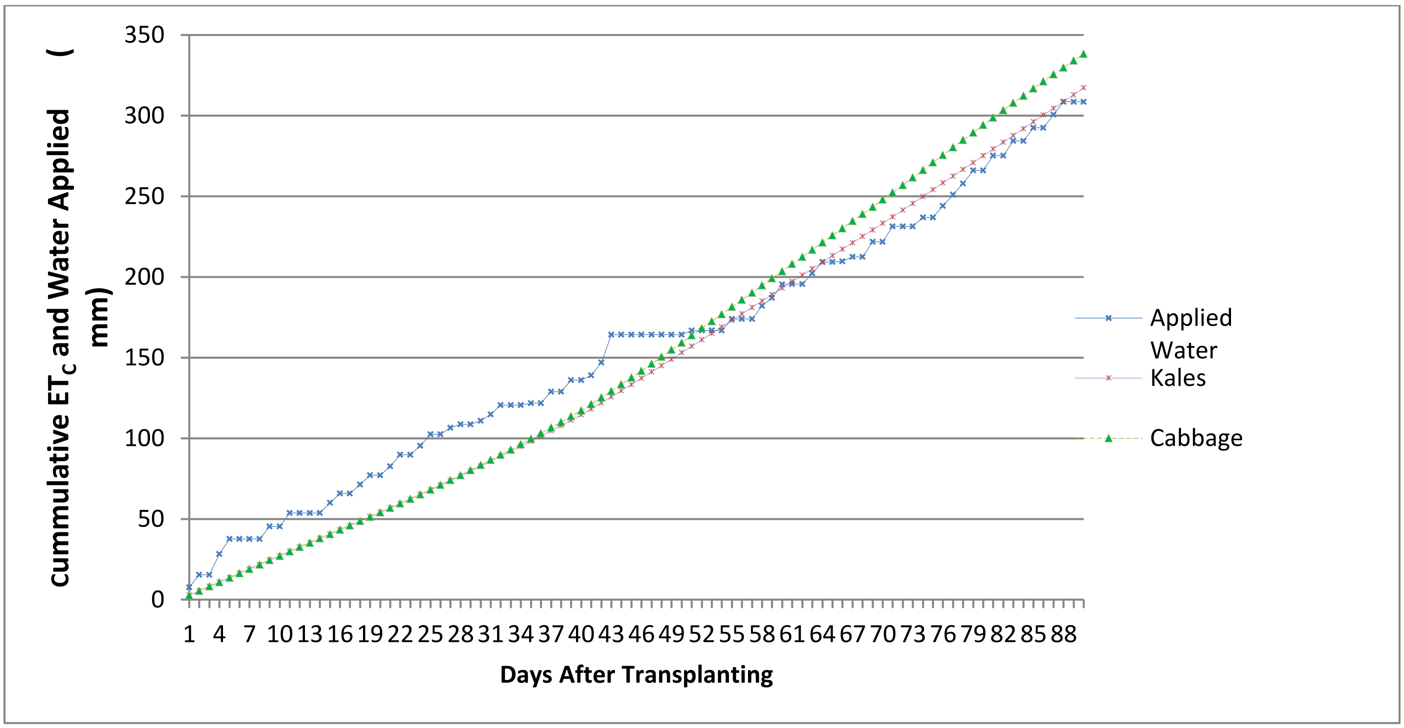

Figure 3 Graph of Cumulative crop water requirements and applied water against time

For cabbages from head formation to the day of harvesting, the cabbage water requirement exceeded the applied water. This showed that cabbage crop underwent water stress during this stage and therefore affected the yields. The water stress for cabbages during the entire period was

91%. During the head formation stage, the water stress 81%. Water stress for cabbages started from day 52 to day 90. For kales, the water stress started from day 54 to day 90 except for days 55, 60, and 64 after transplanting. The water stress for kales during the entire period was 97%. From mid- season stage, the water stress was 88%. This shows that cabbages were more water stressed than kales during the mid season stage onwards owing to their high water demand. The reason for this water stress according to the farmer was attributed to the gardener employed who left and it took time to get another gardener. With the farmer being a lady it was difficult for her to balance between house chores and irrigating the crops at this critical stage of mid season.

Yields and total amount of water

Out of 700 cabbages transplanted only 89 seedlings matured to yield between 0.5 and 1.5 kg. 53 seedlings yielded 0.5 kg, 25 seedlings yielded 1 kg and 11 seedlings yielded 1.5 kg. The total yield was 68 kg for cabbages. The remaining 611 seedlings yielded nothing with the majority of them remaining at cupping stage and head formation stages. This shows that 87% of the seedlings were lost. This loss could be attributed to failure of seedling to recover after transplanting, quality of seeds and cutworms at the initial stages. This means that controlling pests still remain a challenge for farmers.

Out of 160 kale seedlings transplanted, 136 matured to yield 40 kg between day 60 and day 90 after transplanting as shown in Table 1. It shows that 15% of the seedlings were lost due to cutworms and failure of the seedlings to recover when they were being transplanted.

Table 1 Petrol and water use efficiencies for cabbages and kales

Crop	Yield (kg)	Amount of water used (mm)	Total crop water requirement (mm)	Water stress level (%)	Petrol consumed (litres)	Water use efficiency (Kg/m^3)	Petrol Use efficiency (Kg/m^3)
Cabbage	68	309	338	91	8.8	=68/(0.309*160) =1.4	=68/(0.0088) =7727
Kales	40	309	317	97	1.7	=40/(0.309*34) =3.8	=40/(0.0017) =23529

From Table 1, the yield of cabbages and kales were 4.25 tons/ha and 11.8 tons/ha. Kales yield was equal to the average yield of kales in Kenya (MOA Handbook, 2012). Kales had better water and petrol use efficiencies than cabbages. The water use efficiencies were 1.4 Kg/ m^3 and 3.8 Kg/ m^3 for cabbages and kales, respectively. The petrol use efficiencies were 23 529 Kg/ m^3 and 7727 Kg/ m^3 for kales and cabbages, respectively. The water use efficiency for kales was approximately three times that of cabbages while the petrol efficiency was also three times. The cabbage yield of 4.25 tons/Ha was fifteen time less than 67 tons/ha under 50 % water stress observed in Keiyo highlands (Kiptum *et al*., 2013). The yield was eight times lower than 32.9 tons/ha observed in Chikwawa district in Malawi (Kadyampakeni, 2013). The results of cabbages yield agrees with Kadyampakeni (2013) who showed that water stress during the head formation affects yield and head size.

The cabbage production was a quarter of the average production in the country while kales production was almost similar to the average annual production. This means that it is better for the farmer to invest in growing kales than cabbages due to the fact that attaining crop water requirement after day 50 seemed impossible. In addition, growing of kales do not pollute environment as they use less petrol which produces gases that are harmful to the ozone layer and their attendant risks of global warming which has resulted in erratic weather patterns in most parts of the world. Climate change as a result of air pollution from combustion of fossil fuel affects children and increases inequality in society (Perera, 2017). Perera (2017) gives a solution of using solar energy pump in place of petrol pump to reduce the amount of carbon dioxide emissions to the atmosphere.

The study was limited to one season (2017-2018) and to the different plot sizes for kales and cabbages as the farmer had planned. Therefore, yield of both the crops might have been affected by the plot sizes.

CONCLUSIONS AND RECOMMENDATIONS

Kales are more efficient than cabbages in both petrol and water use efficiencies by yielding more. Kales survival rate was higher than that of cabbages. Water and petrol use efficiencies for kales was three times that of cabbages. Cabbages were stressed more than kales and it is therefore recommended that the farmer should concentrate on growing kales than cabbages for better yields. Since this research followed the farmer's way of irrigation means that there is need for further research on the same topic but this time an irrigation schedule for both kales and cabbages to be followed. Should resources permit the same study could be conducted using other varieties of kales and cabbages in a big area of one hectare.

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