

Evaluation of the Effect Mulching Practice Under Furrow Irrigation on Growth, Yield and Water Productivity of Head Cabbage at Adami Tulu Agricultural Research Center

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Abstract: The experiment was under taken among the amount of water and mulching practice at Adami Tulu Agricultural Research Center of experimental site for head cabbage production. With the objective of to investigate and evaluate the effect of furrow irrigation level and mulching on water productivity, yield and yield component of head cabbage. A field experiment was designed as a two factor factorial experiment (2*4) in RCBD, replicated three times. The two factors were irrigation water level and mulching material. Irrigation was applied to furrows using Parshal flume from furrows head ditch with similar inflow rate, but the amount of application of water varies. Results obtained revealed that Application of wheat straw mulch and plastic mulch significantly increased the growth and yield of cabbage. Straw mulch produced total yield of 9.68 ton/ha which was not significantly different with that obtained under White straw mulch (9.69ton/ha). Total yield harvested from black plastic mulch were 9.33ton/ha, which showed insignificant difference between the three mulching material. High yield of 16.60ton/ha was recorded from full irrigation that is 100%ETc and when half of irrigation water applied the yield were 9.4ton/ha which showed significant difference between the two irrigation level. Water productivity of 4.3kg/m³ and 3.8kg/m³ were produced under 50%ETc and 100%ETc or full irrigation water respectively. It was found that 50%ETc irrigation level saved 50% of water as compared to full irrigation and can irrigate additional land with the amount of water saved.

Keywords: Straw Mulch, Irrigation Level, Crop Water Requirement, Water Use Efficiency

1. Introduction

The pressure on agriculture is increasing due to population growth thereby creating a need to improve agricultural production and productivity. There is a growing recognition that increases in food production will largely have to originate from improved productivity per unit water and soil. To meet future food demands and growing competition for water, a more efficient use of water in irrigated agriculture will be essential.

Since the beginning of civilization, man has developed technologies to increase the efficiency of food production. The use of plastic mulch in commercial vegetable production is one of these traditional techniques that have been used since 1950's. A favorable soil-water-plant relation is created

by placing mulch over the soil surface. The microclimate surrounding the plant and soil is significantly affected by mulch i.e. the thermodynamic environment, the moisture, the erosion, the physical soil structure, the incidence of pests and diseases, crop growth and yield.

Vegetable crops are the eminent sources of human nutrition. These are short duration crops, which can be grown even in small spaces. Demand for fresh or canned vegetables is increasing in national and international market. Considering that the world population is estimated to increase by 65% (3.7 billion) by 2050, the demand for food will increase strain on fresh water resources [14]. Increase in area under production of any crop is of no use until economic yield per unit area does not increase. Commercial production of vegetable is not possible without adequate water

availability throughout the growing season. Due to expected scarcity of water in future, water use efficient crops can only cope with the increasing demand.

In order to maximize water use efficiency by the plant and to improve the quality of produce, the use of mulch has become an important cultural practice in many regions of the world for the commercial production of vegetable crops. Mulches can be used to conserve moisture and increase growth. The use of mulches has aided growers in increasing crop production efficiency by promoting favorable moisture and temperature conditions.

Different forms of plastic mulch are available varying from woven plastic to smooth plastic and embossed plastic films. Now-a-days 100% compostable and biodegradable mulches are also available in advanced countries and these are more environments friendly. In addition to the surface structure, the color and thickness of the mulch creates lot of variations which have an effect on the plant microclimate and in particular the soil temperature. Soil temperatures can be increased in the field by applying plastic mulches. They are inert and do not add crop nutrients to the soil by decomposition, but have been successfully used to achieve a number of effects with certain advantages over other mulches (e.g., straw mulches, clear plastic mulches). These advantages include: warming of soil for improved germination and seedling vigor, control of weeds, reduction of evaporation from the soil surface and aiding seed germination by keeping the soil surface moist.

The advent of increasing water scarcity in this century will observe less increase in irrigated land availability for food production than in the past. Novel irrigation technologies need to be tested under local environments and particularly in agricultural production systems of developing countries. While irrigation can benefit yields and enhance water use efficiency (WUE) in water limited environments, the potential for full irrigation is decreasing, with increased competition from the domestic and industrial sectors. Thus, the main challenge confronting both rain fed and irrigated agriculture is to improve WUE and sustainable water use for agriculture. Ethiopia is facing a tremendous challenge in meeting the food needs of rapidly growing population. There are small, medium and large scale irrigation systems in Ethiopia [6]. To this end, both irrigated and dry land cropping areas will have to be developed or improved in the future. However, these tasks will not be easy, the cost of developing large scale and medium scale level irrigation is by now sky rocketing. Therefore, efficient utilization of water resources and development of small scale irrigation schemes at family level is crucial for countries like Ethiopia, which has a huge water resource: yet their population is chronically food insecure.

Traditionally, farmers in the central rift valley of Ethiopia have been using the most conventional surface irrigation system for growing crops during the dry season. However, water resources are becoming scarce resource in the area for crop production due to increasing competition for irrigation water. Efficient use of irrigation water is becoming increasingly important considering the availability of

irrigation water resources and sustaining the production and productivity of growing crops in the area.

The soil moisture status in the root zone regulates plant growth and influences ET. Management practices that influence soil moisture include irrigation techniques, irrigation strategies and mulching practices. The particular irrigation technique influences the way irrigation water is applied, which influences for instance the percentage of surface wetting, which again influences ET [11]. The particular irrigation strategy applied determines how much and when irrigation is applied. The mulching practice determines soil cover and in this way influences non-productive evaporation.

This work will investigate the effects of irrigation water management (in terms of irrigation and cultural practice (mulching)) on head cabbage growth, yield and water use efficiency under AT climatic condition.

Objectives

- To investigate the effect of furrow irrigation level and mulching on yield and yield component.
- To evaluate furrow irrigation levels and mulching on Water productivity of cabbage.

2. Materials and Methods

2.1. Study Area

The experiment was conducted at the experimental site of Adami Tulu Agricultural Research Centre during irrigation time of 2018/19, 2019/20 and 2020/21 for three consecutive years. The area is found at a latitude of 7° 9'N and 38° 7'E longitude at an altitude of about 1650 meters above sea level. The rainfall is bimodal and unevenly distributed with average annual rainfall of 760 mm. The minor and main rainfall periods are from February to April and July to September, respectively.

2.2. Experimental Design and Treatments

Field experiments were carried out during dry cropping season (October – April). Treatments were two level methods of irrigation water and four mulching technique (No mulch [NM], straw mulch [SM], black plastic mulch [BPM] and white plastic mulch [WPM]). The experimental treatments were has been randomized complete block design in RCBD with three replications, in which the irrigation water level methods was used as main plot and the four mulching technique were used as sub-plot.

Table 1. Treatment combination.

Main plot (MP)	Sub plot (SP)			
	NM	SM	BPM	WPM
Full	1	2	3	4
Half	5	6	7	8

2.3. Crop Management Practices

The experimental fields were divided into 24 plots and each experiment plot were had plot sizes of 5m by 5m to accommodate five furrows with spacing of 100cm and with 5m length.. The plots and replications were had buffer zone

of 1.0m and 4.0m between plots on none supplying and supplying canal sides, respectively to eliminated influence of lateral water movement.

The experimental plots were pre-irrigated before two days to planting. Head cabbage was planted on well prepared experimental field plots. Establishment irrigation was applied before the commencement of differential irrigation. The predetermined amount of irrigation water were based on allowable soil moisture depletion for cabbage, each plot were irrigated using Parshall flume.

2.4. Irrigation Management

The amount of water that can be extracted by plant roots is held in the soil in an 'available' form. The actual volume of water that can be obtained from the soil profile depends on the depth of the root system. Not all of the water found in the root zone was actually be taken up by roots. The total available water (TAW), stored in a unit volume of soil, is approximated by taking the difference between the water content at field capacity (FC) and at permanent wilting point (PWP). The TAW is expresses as:

$$TAW = \frac{(FC - PWP) \times BD \times Dz}{100} \quad (1)$$

where FC and PWP in % on weight basis, BD is the bulk density of the soil in gm cm⁻³, and Dz is the maximum effective root zone depth in mm.

The bulk density, BD, is the mass of a soil in a unit volume for undisturbed soil condition and is expressed on dry weight basis of the soil as:

$$BD = \frac{M_s}{V_s} \quad (2)$$

where Ms is the weight of oven dry soil, and Vs is the volume of the same soil in cm³. For maximum crop production, the irrigation schedule should be fixed based on readily available soil water (RAW). The RAW is the amount of water that crops can extract from the root zone without experiencing any water stress. The RAW could be computed from the expression:

$$RAW = p \times TAW \quad (3)$$

Where RAW in mm, p is in fraction for allowable/permisible soil moisture depletion for no stress, and TAW is total available water in mm.

Head cabbage is sensitive to water deficit. For high yield, soil water depletion should not exceed 45% of the TAW (p=45%). Irrigation was discontinued as the crop approaches maturity to allow the tops to desiccate and also to prevent a second flush of roots growth [4]. Soil moisture was monitored gravimetrically and/or using soil moisture measuring device at 20cm soil depth increments up to 40cm soil depth (0-20, and 20-40cm) in a single replication. Permissible soil moisture depletion was taken as 100% ET requirement and all other treatments were then be adjusted accordingly to irrigate the plots. The depth of irrigation supplied at any time can be obtained from a simplified water

balance equation which is expressed as:

$$I_n = ET_c - P_e \quad (4)$$

Where I_n is the net irrigation depth (mm), ET_c is the crop water requirement (mm) and P_e is the effective rainfall (mm).

The gross irrigation requirement was obtained from the expression:

Surface irrigation:

$$I_g = \frac{I_n}{E_a} \quad (5)$$

Where I_g is the gross irrigation depth and E_a is the field application efficiency (%), w.a. is the wetted area (%).

In the case of furrow irrigation, knowing the application efficiency of the furrows, the time required to deliver the desired depth of water into each furrow were calculated using the equation:

$$T = \frac{d \times w \times l}{6 \times Q} \quad (6)$$

Where: d= gross depth of water applied (cm),

t= application time (min),

l= furrow length in (m),

w= furrow spacing in (m), and

Q= flow rate (discharge) (l/s).

Soil moisture depletion at any soil moisture level was observed with the following expression as:

$$SMD = (FC - MC) \times Dz_r \quad (7)$$

Where: SMD = Soil moisture depletion (mm), FC = Volumetric soil moisture content at field capacity (mm), MC = Volumetric moisture content at time of irrigation (mm), and Dz_r = Depth of effective root zone (mm).

2.5. Data to Be Collected

2.5.1. Soil Data

Soil samples was collected from the experimental field using core samples from the soil depths of 0 - 20cm, 20 - 40cm. Soil physical properties like textural class, bulk density, and infiltration rate, OM, FC, PWP and TAW were determined.

Regular soil samples were collected from experimental plots before and after irrigation for gravimetric soil moisture determination. The gravimetric soil moisture is then determined using the expression:

$$SMC (\%) = \frac{W_{ws} - W_{ds}}{W_{ds}} \times 100 \quad (8)$$

Where SMC is the soil moisture content at time of sampling (%), W_{ws} is weight of wet soil (gm) and W_{ds} is weight of dry soil (gm).

2.5.2. Crop Data

Date of planting, maturity and other relevant agronomic parameters were recorded from five randomly selected plants from three middle rows of each experimental plot and these plants were tagged for subsequent measurement.

The center of each plot was harvested for yield and head trait data. The first harvest was occurred when approximately 50% of the cabbage heads reached 1 kg, while all remaining plants were harvested during a second harvest. Cabbage is harvested by cut-ting the stem at the soil surface. The heads were weighed before and after the removal of the outer wrapper leaves. Cabbage heads were classified as marketable when trimmed head weight is above 1 kg and unmarketable for head weight below 1 kg. Total cabbage yield were calculated as marketable and unmarketable trimmed heads. A total of 40 cabbage heads from furrow 20 head cabbage (5 per heads per row) per plot and 20 head cabbage (5 per heads per row) per plot was randomly selected for internal quality evaluation. Measurements of cabbage head equatorial and polar diameter, core length, and core base width were recorded. Cabbage heads were treated as a sphere for the head volume calculation and cores were treated as a cone for the volume calculation, as described by [9].

2.5.3. Climatic Data

Data on daily climate of the site were collected from the meteorological station observatory. The reference evapotranspiration (ET_o) was computed using Penman-Monteith method, CROPWAT ver. 8.0 window based computer model from the climatic data gathered from station. The cabbage crop evapotranspiration (ET_c) for each day were computed by multiplying the ET_o by the crop coefficient (K_c) values obtained from FAO [5], for each of the four stages of cabbage viz., initial, development, mid and late season. The K_c values represented the ratio of crop evapotranspiration (ET_c) and reference evaporation (ET_o) rate each day. The effective rain fall were computed by the CROPWAT program from the monthly total rainfalls. The net daily crop water requirement was computed by reducing the ET_c by the daily effective rainfall. The gross water requirements were computed by applying field application efficiency.

2.6. Water Use Efficiency

The water use efficiency was calculated by dividing harvested yield in kg per unit volume of water used.

Crop water use efficiency: The crop water use efficiency is the yield harvested per ha-mm of total water used.

$$CWUE = \frac{Y}{ET_c} \quad (9)$$

Where: CWUE = crop water use efficiency (kg/ha-mm);

Y = yield in kg ha⁻¹ and;

ET = is evapotranspiration (mm).

Field water use efficiency: Field water use efficiency is the yield harvested per ha-mm of net depth infiltrated.

$$FWUE = \frac{Y}{I_n} \quad (10)$$

Where: FWUE = field water use efficiency (kg/ha-mm);

Y = yield in (kg/ha);

I_n = Net irrigation is in (mm).

2.7. Data Analysis

The effect of furrow irrigation under mulching on the growth and yield of head cabbage were analyzed using SAS software. The data collected were statistically analyzed following the standard procedures applicable to split plot for RCBD. When the treatment effects are found significant, LSD test was performed to assess the difference among treatments means.

3. Result and Discussion

The experiment was conducted to determine the Yield and water use efficiency of head Cabbage Influenced by Different Mulch Practices. The analysis of variance (ANOVA) of the data on different yield components and yield of head cabbage are determined. The results have been presented and discussed, and possible interpretations have been given.

According to Ramakrishna et al. [12], evaporation from the soil accounts for 25-50% of the total quantity of water used. Yield components were significantly reduced by covering material when measured at harvest. Significantly reduced head fresh weight, height and width,

Table 2. The effects of mulching material and irrigation depth on yield components of head cabbage.

Treatments		Head Equatorial	Polar Diameter	Base width	Base Length
Irrigation depth	D1	13.26 ^a	12.29 ^a	9.94 ^a	5.89 ^a
	D2	11.77 ^b	11.43 ^b	4.77 ^b	4.64 ^b
	LSD	0.97	0.83	1.17	0.3
	NM	10.72 ^b	10.22 ^{bc}	7.30 ^b	5.15 ^b
Mulch type	SM	12.38 ^a	11.83 ^a	9.87 ^{ab}	5.90 ^a
	BM	11.86 ^{ab}	11.66 ^{ab}	10.53 ^a	6.20 ^a
	WM	10.10 ^b	10.02 ^c	11.08 ^a	5.88 ^{ab}
	LSD	1.78	1.57	2.90	0.73
	CV	9.06	9.76	13.32	10.77

*D1=100%ET_c, D2=50%ET_c, NM=No Mulch, SM= Straw Mulch, BPM=Black Plastic Mulch, WPM=White Plastic Mulch.

3.1. Head Equatorial and Polar Diameter

The main effects of mulch types/ cover material on

cabbage head equatorial development were not significant different between Wheat straw mulch (12.38 cm) and black plastic mulch (11.86 cm), but significantly different with

white plastic mulch (10.10 cm) and bare soil (10.72 cm) (Table 1). The effects of mulch types/ cover material on cabbage polar diameter development were significant. Wheat straw mulch (11.83 cm), black plastic mulch (11.66 cm) and bare soil (10.22 cm) had significantly higher means than white plastic mulch (10.02 cm) (Table 1). White plastic mulch had significantly lower means. Cabbage head diameter in BPM and wheat straw mulch was not statistically different.

3.2. Base Width and Base Length

White plastic mulch had significantly higher means (11.08 cm) than black plastic mulch (10.53 cm) and straw mulch (9.87 cm) on base width. On the other hand black plastic mulch had significantly higher means (6.20 cm) than straw mulch (5.9 cm) and white plastic mulch (5.88 cm) on base length and the lowest base width were recorded on bare soil or control treatment (5.15 cm).

Results of this study agree with findings by Decoteau, et al and Yang et al. [3, 16], which showed that mulching in general has a positive effect on plant height, leaf numbers and size, shoot diameter and dry matter. Cabbage head diameter in BPM and wheat straw mulch was not statistically

different. Bare soil had significantly lower means. There was no significant difference in yield between the black plastic and wheat straw mulch types.

Results shows that the main effects of irrigation depth material on cabbage head equatorial development were significant different. The highest values 13.26cm were recorded when full amount of irrigation water applied and higher than with half of water applied which is 11.77cm.

Black plastic mulch had significantly higher means 10.53cm, 6.2cm than wheat straw mulch 9.87cm, 5.9cm on base width and length respectively. On the other hand full irrigation had significantly higher means 9.94cm, 5.89cm than when half of the water applied which was 4.77cm, 4.64cm on base width and length respectively.

3.3. The Main Effect of Mulch Type and Irrigation Depth on Cabbage Yield

The effect of mulch type was significant ($P < 0.05$) on cabbage yield (Table 3). Wheat straw mulch had significantly higher mean weight per cabbage head when compared with the other on weight of head cabbage per plant. The values were 2240g for wheat straw mulch, 2160g for white plastic, 2070g for black plastic and 1383g for bare soil.

Table 3. The effects of mulching material and irrigation depth on yield of head cabbage.

Treatments		Head weight before/plant (g)	Head weight After/plant (g)	Yield ^{br} (ton/ha)	Yield ^{ar} (ton/ha)
Irrigation depth	D1	2419.8 ^a	1660 ^a	24.20 ^a	16.60 ^a
	D2	2113.3 ^a	1410.7 ^a	14.09 ^b	9.40 ^b
	LSD	459.6	340.3	3.93	2.93
	NM	1383 ^b	901 ^b	9.22 ^b	5.91 ^b
Mulch type	SM	2240 ^a	1453 ^a	14.93 ^a	9.68 ^a
	BPM	2070 ^a	1400 ^{ab}	13.80 ^{ab}	9.33 ^{ab}
	WPM	2160 ^a	1453 ^a	14.40 ^a	9.69 ^a
	LSD	713	546	4.75	3.64
	CV	25.81	30.72	25.82	30.71

*D1=100%ETc, D2=50%ETc, NM=No Mulch, SM= Straw Mulch, BPM=Black Plastic Mulch, WPM=White Plastic Mulch.

There was no significant difference in yield between the black plastic and wheat straw mulch types. Results of this study agree with findings by Chantal et al. [2], that straw mulch and black plastic mulch have the same response on yield. The means for wheat straw were significantly higher than for black plastic mulch.

3.4. Effect of Mulch Type on Yield of Cabbage

Application of wheat straw mulch and black plastic mulch significantly increased the growth and yield of cabbage than bare soil. This may have been due to the ability of mulch to retain moisture in soil and increase the plants' water use efficiency [15]. Black plastic mulch additionally increases soil temperature and reduces weeds [7, 10] and this promoted cabbage growth compared to bare soil.

3.5. Interaction Effect on Cabbage Yield Component

There is no significance difference on interaction effect

among all the treatments on head equatorial and base length. But there is significance difference in interaction effects among the treatment on polar diameter and base width. The highest value were recorded on treatment 6 when straw mulch applied which is 12.87cm, 8.53cm and the lowest value were recorded 10.78cm, 5.4cm on bare soil with half of irrigation depth applied (T5) on polar diameter and base width respectively.

3.6. The Interaction Effect on Total Yield of Cabbage

There is no significance difference in interaction effect among the treatments on weight of head/plant before and after the removal of the outer shell of the leaves And also there is no significance difference among the treatments on total yield of cabbage. The highest yield were recorded 22.37ton/ha on treatment 3 which is when black plastic mulch with full irrigation followed by 21.76ton/ha of treatment 6 when straw mulch applied half of irrigation depth.

Table 4. Interaction Effect on cabbage yield component.

Treatment	Head Equatorial	Polar Diameter	Base width	Base Length
T1	12.33 ^{ns}	11.34 ^{ab}	7.17 ^{ab}	5.01 ^{ns}
T2	12.50 ^{ns}	11.92 ^{ab}	6.28 ^{ab}	5.14 ^{ns}
T3	12.60 ^{ns}	12.37 ^{ab}	7.50 ^{ab}	5.46 ^{ns}
T4	12.35 ^{ns}	11.88 ^{ab}	8.02 ^a	5.36 ^{ns}
T5	11.83 ^{ns}	10.78 ^b	5.40 ^b	4.99 ^{ns}
T6	13.77 ^{ns}	12.87 ^a	8.53 ^a	5.35 ^{ns}
T7	12.73 ^{ns}	12.27 ^{ab}	7.97 ^a	5.59 ^{ns}
T8	11.98 ^{ns}	11.44 ^{ab}	7.99 ^a	5.21 ^{ns}
LSD	1.95	1.67	2.35	0.61
CV	12.60	11.34	25.79	9.43

*D1=100%ETc, D2=50%ETc, NM=No Mulch, SM= Straw Mulch, BPM=Black Plastic Mulch, WPM=White Plastic Mulch.

Table 5. Interaction Effect on total yield of cabbage.

Treatment	Head weight before/plant (g)	Head weight After/plant (g)	Yield ^{br} (ton/ha)	Yield ^{ar} (ton/ha)
T1	2040.0 ^{ns}	1480.6 ^{ns}	16.88 ^{ns}	12.37 ^{ns}
T2	2402.2 ^{ns}	1552.7 ^{ns}	20.53 ^{ns}	13.35 ^{ns}
T3	2602.2 ^{ns}	1802.8 ^{ns}	22.37 ^{ns}	15.47 ^{ns}
T4	2380.8 ^{ns}	1692.9 ^{ns}	20.39 ^{ns}	14.53 ^{ns}
T5	1810.0 ^{ns}	1192.8 ^{ns}	15.01 ^{ns}	9.91 ^{ns}
T6	2573.9 ^{ns}	1783.3 ^{ns}	21.76 ^{ns}	15.17 ^{ns}
T7	2178.9 ^{ns}	1422.2 ^{ns}	18.54 ^{ns}	12.11 ^{ns}
T8	2144.4 ^{ns}	1355.6 ^{ns}	17.67 ^{ns}	11.11 ^{ns}
LSD	919.2	680.64	7.86	5.87
CV	32.8	35.8	33.16	36.48

*D1=100%ETc, D2=50%ETc, NM=No Mulch, SM= Straw Mulch, BPM=Black Plastic Mulch, WPM=White Plastic Mulch.

3.7. Water Use Efficiency of Cabbage

The highest WUE value under limited water supply, i.e. 7.0kg/m³ and 5.6kg/m³, was observed to the treatment 6 and Treatment 7 with 50%ETc of irrigation depth consecutively. The results agree with [1, 11, 13, 17] mulching improves

crop production and increase water-use efficiency. The total water used by applying of mulching reduced to some extent that contributes to increment of total water use efficiency. This finding also agreed with result states that an adverse relationship was found between the amounts of water applied and water productivity of the crop by [8].

Table 6. The interaction effects of water use efficiency on head cabbage.

Treatment	Yield (Qt/ha)	CWR (mm)	Applied water (mm)	CWUE (kg/m ³)	IWUE (kg/m ³)
T1	123.7	380.5	432.8	0.33 ^c	0.29 ^c
T2	133.5	380.5	432.8	0.35 ^{bc}	0.31 ^{bc}
T3	154.7	380.5	432.8	0.41 ^{ab}	0.36 ^{ab}
T4	145.3	380.5	432.8	0.38 ^{bc}	0.34 ^{bc}
T5	99.1	190.25	216.4	0.52 ^{ab}	0.46 ^{ab}
T6	151.7	190.25	216.4	0.80 ^a	0.70 ^a
T7	121.1	190.25	216.4	0.64 ^a	0.56 ^a
T8	111.1	190.25	216.4	0.58 ^{ab}	0.51 ^{ab}

There is significant difference (P<0.05) between the results of CWUE of irrigation depth and mulching. The three mulching material were better performance at reduced water

application level. In addition, straw mulch was better than black plastic mulch and white plastic mulch at all reduced amount application level.

Table 7. Main effects of water use efficiency on head cabbage.

Treatments		Yield (Qt/ha)	CWR (mm)	Applied water (mm)	CWUE (kg/m ³)	IWUE (kg/m ³)
Irrigation depth	D1	166	380.5	432.8	0.44 ^b	0.38 ^b
	D2	94	190.25	216.4	0.49 ^a	0.43 ^a
	NM	59.1	380.5	432.8	0.16 ^b	0.14 ^b
Mulch type	SM	96.8	380.5	432.8	0.25 ^a	0.22 ^a
	BM	93.3	380.5	432.8	0.25 ^a	0.22 ^a
	WM	96.9	380.5	432.8	0.25 ^a	0.22 ^a

3.8. Economic Analysis

The economic analysis of plastic mulching material when compared to the un mulched is highest on material cost but

the bare soil and straw mulch were incurred the same amount of total cost due to straw mulch decreases the cost of weeding when compared with bare soil.

Table 8. Economic Analysis of profitability of mulching.

Parameters	Mulching material			
	NM	SM	BPM	WBM
Material cost (birr)	00.00	10000.00	42000.00	42000.00
Labor cost (birr)	25000	15000	15000	15000
Input cost cost (birr)	10000	10000	10000	10000
Average Total cost (birr)	35000	35000	67000	67000
Yield gained (kg)	59100	96800	93300	96900
Average sale price (kg/birr)	7	7	7	7
Average gross Return (birr)	413700	677600	653100	678300
Average Net return (birr)	378700	642600	586100	611300

The average net return of straw mulch is greater than when compared with other mulching material and also with compared to the net benefit gained with the bare soil. The highest net benefit gained 642,600 birr on straw mulch and 611300birr and 586100birr on white plastic mulch and black plastic mulch respectively and the least net benefit gained 378700birr from the bare soil/un mulched of the treatment.

4. Conclusion and Recommendation

Use of plastic and straw mulch was beneficial in retention of soil moisture and suppression of weeds. This resulted in enhanced stem diameter development compared to the control (bare soil).

Water regulates plant development by performing three basic functions; mediates environmental effects on growth and metabolism, correlates the growth of different parts of the plant, and integrates growth and metabolic activity at the cellular level.

Different mulches applied in the head cabbage field had significant effect on different parameters. Results exposed that the highest head equatorial (12.38cm and 11.86cm at straw mulch and black plastic mulch, respectively), the maximum polar diameter (11.83 and 11.66cm at straw mulch and black plastic mulch, respectively), the maximum base width (11.08 and 10.53cm at white plastic mulch and black plastic mulch, respectively), the maximum base length (6.2 and 5.9cm at black plastic mulch and straw mulch, respectively), the maximum head weight before removal per plant (2240 and 2160gm at straw mulch and white plastic mulch, respectively), were recorded straw mulch treatment. Again the maximum total yield after removal of outer leaves of head (9.69 and 9.68 at plastic mulch and straw mulch).

The study on “effect of mulch type on growth and yield of cabbage in the study area revealed that:

- Application of the black plastic and wheat straw mulch influenced positively plant growth and yield because of capacity of mulch to retain moisture for increased nutrient uptake.
- Black plastic and wheat straw mulches generated higher soil moisture compared to the control.

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