BIBLIOGRAPHY

COMILA, JACKER G. May 2008 Performance of Broccoli *(Brassica oleraceae var. Italica)* as Affected by Frequency of Irrigation. Benguet State University, La Trinidad, Benguet

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ABSTRACT

This study was conducted at the Balili Experiment Farm, Benguet State University, La Trinidad, Benguet from January to March 2008 to determine the effect of frequency of irrigation on the growth and yield performance of Broccoli.

Findings indicate that growth and yield of broccoli were greater with more frequent irrigation at two or four days interval but the return investment was highest with long irrigation interval at eight days on amount of lower cost incurred in irrigation.

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INTRODUCTION

In Benguet, the source of livelihood is vegetable farming. Broccoli is one of the popular and high value vegetable being grown. To obtain high yield and quality of the crop appropriate cultural practices must be employed. Among them is irrigation or supply of water at the proper time to promote growth and development.

Broccoli is a plant of the cabbage family, Brassicaceae (formerly Cruciferae). It is classified as the Italica Cultivar Group of the species Brassica oleraceae. Broccoli possesses abundant fleshy green flower heads arranged in a tree-like fashion on branches sprouting from a thick, edible stalk. The large mass of flower heads is surrounded by leaves. Broccoli most closely resembles cauliflower, which is a different cultivar group of the same species, but broccoli is green rather than white.

The requirements of broccoli are similar to those of cauliflower but generally less sensitive to high temperature; optimum temperature are in the range of 18-24 C. High temperature may accelerate maturity and induce early flowering. Broccoli also has a lower requirement than cauliflower for a cool period of flowering.

The period taken to reach maturity is generally similar to that required by cauliflower, the crop maybe harvested 80-140 days from transplanting. The heads are harvested with 15-25 cm of stem attached, immediately prior to opening of the flowers. After the terminal head has been harvested, several lateral buds developed, to be harvested successionally over a period of several weeks

One should recognize that irrigation water is always associated in the production of crops. Water is chemically bond in the form of hydrogen and oxygen ions in various plant compounds. The total amount of bound water is estimated to be approximately 60% of dry weight in the plant tissues. Water is also present in the living tissues. The living plants are generally considered to contain about 60 to 90 percent water. (Caoili et al, 1967)

Hansen (1979) stated that economics is important in evaluation irrigation practices, for irrigation is largely for the purpose of increasing profit. Higher profits resulting from more efficient production will ultimately result in lower prices for consumers and lower prices will result in more consumption of food and results in higher standard of living.

The study was conducted to determine the effect of irrigation frequency and ascertain the best irrigation interval for broccoli production.

This study was conducted at the Balili Experiment Farm, Benguet State University, La Trinidad Benguet from January to March 2008.

REVIEW OF LITIRATURE

Description of the Crop

Broccoli (*Brassica oleracea var. Italica*) belongs to the family brassicaceae. This crop is native of western Asia and eastern Mediterranean Boswell 1970 as cited by (contada). Broccoli is said to have come from Italy, Cypress or Eastern Mediterranean area in the 17th century.

Broccoli is nutritious garden vegetable closely related to cauliflower. It has thick cluster of flower buds that form edible 'heads" (Richard, 1995). Broccoli heads are green with more branches and open than the tight, round, white heads of cauliflower. The height ranges from two to three feet that bears dense cluster of flower buds at the end of the flower axis and the branches (Benton, 1970).

Bachelor (1998) said that the yield variability results from complex interactions between the environment, genetics, management, and biotic stress that occur across a field. Of these factors, water stress is one of the major causes of yield variability in fields. Water stress occurs when roots cannot supply enough water to satisfy evaporative demand of water transpiring from leaves. Root water uptake is a function of soil water availability, root depth and density, and location of roots relative to water in the soil. Plant genetics also can influence root growth and development, and subsequently water uptake, by influencing location of roots relative to water in the soil. Daily evaporative demand driving transpiration and potential water stress is a function of uncontrollable environmental factors, including temperature, relative humidity, and wind speed. Water stress reduces photosynthesis, resulting in reduced crop growth and yield.

Bachelor (1998) cited that minor water stress often occurs for short periods during the hottest part of the day, late in the season. Water stress can vary across a field, depending upon soil type, moisture-holding capacity, and drainage characteristics. The integration of variable water stress each day over the season can result in reduced photosynthesis and variable yield loss across a field. Because of the dynamic nature of water stress, it is very difficult to measure and correlate to final yield.

Irrigation

Water is precious component of human life. The ways by which it sustains everyday activities are innumerable. In the field of agriculture particularly irrigation systems and irrigated farm unit, essentiality of water has forced men to manage it effectively (PCARRD, 1983 cited by Cadpino 2007)

According to Hansen (1979), the units of water measurement are considered in two classes; fist those expressing a specific volume of water at rest. Second, those expressing a time rate of flow. The commonly used units of volume of water at rest are the liter, cubic, meter, hectare cm, and hectare meter. A hectare cm is a volume of water sufficient to cover one hectare one centimeter deep, 100 cubic meters. A Hectare – meter of water will cover one hectare one meter deep and it is equal to 10 000 cubic meters

However, (Kinoshita, 1979) said that the water absorption ability of crops increases with the increase in the size of plant above ground, but differs greatly depending on the soil temperature. In other words, when the soil temperature is high, the amount of water absorption increases and the increase in the amount of water and oxygen in the soil promotes the water absorption ability of the plant.

According to (Tindall, 1983) the crop should be irrigated regularly, since dry soil conditions may result in reduced yield. Tindall stated that broccoli is more drought resistant than cauliflower. Knott, (1967) said that the crop is relatively shallow rooted. It is important that the moisture content of the soil be maintained in the upper half range of the available moisture. Lack of water will reduce the size of the marketable head curd, delay in maturity at lower quantity.

Caoili and De Vera, (1986) stated that rainfall is considered as irrigation if effective when it can be used by the crops. Every irrigation systems requirement must be based on the some estimated effective rainfall. The higher the percentage of effective rainfall, the smaller the irrigation water required. Irrigation water should fill the soil moisture reservoir between field capacity and wilting point and should be available to crops without causing under moisture stress

Schwab (1993) said that irrigation provides one of the greatest opportunities for increasing crop production as well as improving germination, controlling air temperature, and applying chemicals with the irrigation water. If annual rainfall is less than 250 mm, Irrigation becomes necessity. More over, if rainfall is from 250 to 500mm, then crop production is limited unless the land irrigated; and when the rainfall is more than 500 mm irrigation is often required for maximum production.

MATERIALS AND METHODS

Materials

The materials used in the study were Broccoli seeds (‘Legacy’), fertilizer, insecticide, fungicide, 15 liter pail, hose, and watering can.

Methods

Experimental design and treatment. The experiment was laid out following the Randomized Complete Block Design (RCBD) with four replications. The treatments were represented as fallows:

Code	Irrigation interval (days)
I_1	Two
I_2	Four
I_3	Six
I_4	Eight

Land preparation. An area of 80 sq m was thoroughly prepared and divided into four blocks consisting of four 1x5 sq m plots per block.

Transplanting. Five weeks old seedlings was transplanted 30 cm between hills and 40 cm between rows.

Irrigation. Irrigation was done before and just after transplanting and every other day for two times after which the irrigation treatments were imposed. Fifteen liters per plot were applied during the first three weeks, 30 liters during the next three weeks and 45 liters during the remaining weeks.

Care and maintenance Except for irrigation, all other recommended practices required in the production of broccoli such as fertilizer application, weeding cultivation, and pest control were uniformly employed to each treatment plot.

Harvesting The curds were harvested by cutting 15-20 cm length from top of the curd.

Data Gathered

1. Number of days from transplanting to curd formation. This was taken by counting the number of days from transplanting up to the 50% of the plants had visible curds.

2. Number of days from transplanting to harvesting. This was the number of days from transplanting to the day curds attained harvestable stage (flower buds are still tightly closed and curds fully expanded).

3. Curd circumference (cm). This was measured around the edge of the curds during harvest from six sample curds.

4. Plant height (cm). This was obtained by measuring six sample plants from the base to the tip of the plant during harvest time.

5. Total yield (kg/5 sq m plot). This was the total weight of marketable and non - marketable curds.

6. Non- marketable yields (kg/5 sq m plot). This was the weight of curds that were damaged or malformed.

7. Marketable yield (kg/5 sq m plot). This was the weight of curds without defects.

8. Computed marketable yield (t/ha). The marketable yield per plot was converted to a yield per hectare by multiplying it by 2.000.

9. Average curd weight. Six sample curds were weighed and the weight was divided by number of sample plants.

10. Cost and return analysis. All the expenses incurred and sales were recorded. The return on investment (ROI) was computed using this formula:

$$ROI\ (\%) = \frac{\text{Gross sales- Expenses}}{\text{Total expenses}} \times 100$$

11. Documentation. Pictures were taken to document the study.

12. Meteorological data. Temperature, relative humidity and rainfall were taken during the study period.

RESULTS AND DISCUSSION

Days to curd Formation and Harvesting

Table 1 shows the number of days from transplanting to visible curd formation and transplanting to harvesting as affected by frequency of irrigation. Statistical analysis indicates that every two days of watering significantly enhanced earlier formation of curds. Every four, six and eight days irrigation interval delayed the formation of curds.

As to the number of days from transplanting to harvesting, no signicant effect of irrigation frequency was observed (Table 1). However; plants irrigated every two days were harvested earlier at around 59 days.

Table 1.Days from transplanting to curd formation and harvesting

IRRIGATION INTERVAL (days)	CURD FORMATION (days)	HARVESTING (days)
Two	50.75b	58.75a
Four	54.25a	62.00a
Six	54.00a	61.75a
Eight	55.00a	63.00a

Means in a column with same letter are not significantly different at 5% level by DMRT

Plant Height, Curd Circumference, Average Curd weight

Table 2 shows that plants irrigated every two or four days were significantly taller. There were no significant differences observed in curd circumference and average in weight. However, plants irrigated in two days interval had wider and heavier curds.

Table 2. Plant height, curd circumference and average curd weight

IRRIGATION INTERVAL (days)	PLANT HEIGHT (cm)	CURD CIRCUMFERENCE (cm)	AVERAGE CURD WEIGHT (g)
Two	67.292a	27.793a	520.833a
Four	63.792ab	27.415a	466.665a
Six	60.057b	26.500a	358.417a
Eight	59.458b	26.501a	420.835a

Means in a column with same letter are not significantly different at 5% level by DMRT.

Curd Yield

Table 3 shows that the marketable, non-marketable, and computed marketable as affected by frequency of irrigation were comparable among all the treatment. How ever, plants irrigated every two days had the highest marketable yield at 48 t/ha. Total yield was significantly higher with two or four days irrigation interval.

This indicates that more frequently irrigated plants have higher yield.

Table 3. Curd Yield

IRRIGATION INTERVAL	YIELD (kg/ 5 sq m plot)			COMPUTED MARKETRABLE
	MARKETABLE	NON-MARKETABLE	TOTAL	(t/ha)
Two	24.000a	2.625a	27.125a	48.00a
Four	20.912a	4.563a	23.800ab	41.82a
Six	20.025a	2.938a	22.963b	40.05a
Eight	18.625a	3.813a	21.000b	37.25a

Means in a column with the same letter are not significantly different at 5% level

Economic Analysis

The cost and return analysis in Broccoli production as affected by frequency of irrigation is shown in Table 4. Although more frequently irrigated plants have higher yield, the highest return on investment was obtained from the least irrigated plants at eight days interval at 59.94% ROI. This attributed to the lower cost of fuel and labor incurred in said treatment.

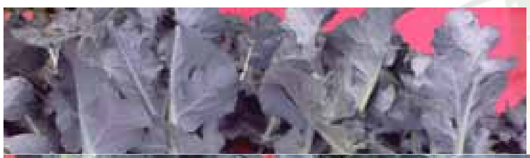
Table 4. Cost and return analysis

	FREQUENCY OF IRRIGATION (Days)			
ITEMS	TWO	FOUR	SIX	EIGHT
Yield (kg)	96	83.65	80.10	74.50
Gross Sales (PhP)	1,440.00	1,254.75	1,216.50	1,117.50
Expenses (PhP)				
Seedling	73.75	73.75	73.75	73.75
Chicken dung	80.00	80.00	80.00	80.00
14-14-14	31.25	31.25	31.25	31.25
46-0-0	30.00	30.00	30.00	30.00
Daconil	71.25	71.25	71.25	71.25
Steward	71.25	71.25	71.25	71.25
Sumicidin	38.75	38.75	38.75	38.75
Anaa	25.00	25.00	25.00	25.00
Gasoline	86.06	40.69	26.75	19.76
Labor				
Land preparation	35.15	35.15	35.15	35.15
Transplanting	1.75	1.75	1.75	1.75
Fertilizer application And hilling up	11.71	11.71	11.71	11.71
Thinning and Weeding	14.06	14.06	14.06	14.06
Irrigation	625.25	318.42	262.50	150.00
Total labor	718.92	381.42	325.17	212.67
Transportation	45.00	45.00	45.00	45.00
Total Expenses	1,271.235	888.36	818.17	698.68
Net Income	168.765	366.39	398.33	418.80
ROI%	13.28	41.24	48.68	59.94
Rank	4	3	2	1

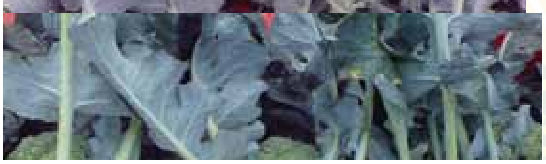
Note: Selling prize was 15 per kilo

Pictorial Presentation

Plate 1. Overview of the experiment field



Two Days Irrigation Interval
Four Days Irrigation Interval



Six Days Irrigation Interval
Eight Days Irrigation Interval

Plate 2. Sample curds harvested from the irrigation treatments plants.

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eteorological Data

Month		Rainfall	Relative Humidity (%)	Temperature Maximum	Temperature Minimum
January		0	85.8	24.60	14.2
		2.2	87.4	24.60	12.1
		Trace	81.4	23.70	14.7
		.2	86.4	24.70	14.9
		0	78.0	25.26	12.0
	Total	2.40	419.00	122.86	67.9
	Mean	0.48	83.80	24.57	13.58
February		.9	78.2	25.1	10.8
		Trace	97.8	23.1	13.3
		3.9	83.7	24.8	15.7
		11.7	96.0	26.8	17.2
	Total	16.5	355.7	99.8	57.0
	Mean	4.13	88.93	24.95	14.25
March		2.1	81.5	24.2	3.1
		3.1	85.6	25.6	13.4
	Total	5.1	67.1	49.8	26.5
	Mean	2.6	83.55	24.90	13.25

The mean rainfall was 0.48, 4.13 and 2.6; relative humidity was 83.30, 88.93 and 83.55: maximum temperature was 24.57, 24.95, and 24.90; while the minimum temperature was 13.58, 14.25 and 13.25 in January, February and March, respectively.

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

This study was conducted at the Balili Experiment Farm, Benguet State University, La Trinidad, Benguet from January to March 2008 to determine the effect of irrigation frequency and ascertain the best irrigation interval for Broccoli.

Results revealed that day to harvesting; curd circumference; average curd weight; marketable, non marketable, and computed marketable yield were not significantly affected by irrigation interval.

However, plants irrigated more frequently every two or four days were significantly taller and had higher total yield. Return on investment was highest at eight days irrigation interval due lesser cost in irrigation.

Conclusion

Although growth and yield were higher at two or four days irrigation interval, return on investment was highest at eight days irrigation frequency.

Recommendation

Based on the result of the study, it is recommended that broccoli could be irrigated at eight days interval in January to March to obtain higher profit.

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APPENDICES

Appendix Table 1. Number of days from transplanting to curd formation

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	52	50	50	51	203.0	50.75
T_2	54	55	54	54	217.0	54.25
T_3	51	55	55	55	216.0	54.00
T_4	57	52	57	56	222.0	55.50

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	2.750	0.917			
Factor A	3	49.250	16.417	4.97*	3.86	6.99
Error	9	29.750	3.306			
Total	15	81.750				

* highly significant coefficient variation: 3.39%

Appendix Table 2. Number of days from transplanting to harvesting

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	60	58	58	59	235.0	58.75
T_2	62	63	61	62	248.0	62.00
T_3	58	63	63	63	247.0	61.75
T_4	64	62	65	61	252.0	63.00

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	1.250	0.417			
Factor A	3	40.250	13.417	3.74ns	3.86	6.99
Error	9	32.750	3.583			
Total	15	73.750				

*ns=not significant coefficient variation: 3.08%

Appendix Table 3. Curd circumference (cm)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	26.67	29.00	28.00	27.50	111.170	27.54
T_2	28.33	27.83	27.33	26.17	109.660	27.41
T_3	29.00	26.00	26.33	24.67	106.000	26.50
T_4	26.33	25.50	29.17	25.00	106.000	26.50

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	8.773	2.924			
Factor A	3	5.158	1.719	0.91ns	3.86	6.99
Error	9	16.926	1.881			
Total	15	30.587				

*ns=not significant coefficient variation: 5.07%

Appendix Table 4. Plant height (cm)

	REPLICATION					
TREATMENT	I	II	III	IV	TOTAL	MEAN
T_1	66.17	60.17	70.83	72.00	269.17	67.29
T_2	65.00	54.67	68.33	67.17	255.17	63.79
T_3	58.00	59.67	63.00	59.50	240.23	60.04
T_4	56.33	53.83	63.17	64.50	237.83	59.46

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	224.502	74.834			
Factor A	3	159.085	53.028	6.59*	3.86	6.99
Error	9	72.786	8.087			
Total	15	456.373				

*highly significant coefficient variation: 4.54

Appendix Table 5. Average curd weight (g)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	491.67	458.33	458.33	583.33	2083.33	520.83
T_2	525.00	475.00	458.33	408.33	1866.66	466.67
T_3	350.00	350.00	391.67	300.00	1541.67	385.42
T_4	491.67	333.33	441.67	416.67	1683.34	420.84

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	7513.520	2504.507			
Factor A	3	41226.787	13742.262	2.20ns	3.86	6.99
Error	9	56291.026	6254.558			
Total	15	105031.333				

*ns =not significant coefficient variation: 17.64%

Appendix Table 6. Non –Marketable Yield (kg/5 sq m plot)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	1.00	0.75	5.75	3.50	10.50	2.63
T_2	4.75	4.75	3.00	5.75	17.50	4.38
T_3	1.00	5.50	3.50	1.75	11.75	2.94
T_4	5.50	1.50	3.75	4.50	15.25	3.81

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	3.324	1.108			
Factor A	3	9.230	3.077	0.96ns	3.86	6.99
Error	9	40.129	4.459			
Total	15	81.750				

*ns= not significant coefficient variation: 60.60%

Appendix Table 7. Marketable yield (kg/5 sq m)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	30.50	27.70	14.80	23.00	96.00	24.00
T_2	23.30	19.05	17.30	24.00	83.65	20.91
T_3	25.50	19.50	16.50	18.60	80.10	20.03
T_4	15.50	21.70	21.80	15.50	74.50	18.63

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	81.212	27.071			
Factor A	3	62.204	20.735	1.06ns	3.86	6.99
Error	9	175.895	19.544			
Total	15	319.311				

*ns=not significant coefficient variation: 21.16%

Appendix Table 8. Total Yield (kg/5 sq m)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	31.50	27.90	20.55	28.50	108.50	27.13
T_2	28.05	23.05	21.05	23.05	95.20	23.80
T_3	25.50	25.00	20.00	20.35	91.85	22.96
T_4	21.00	20.50	19.00	20.00	84.00	21.00

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	92.055	30.685			
Factor A	3	78.290	26.097	5.67*	3.86	6.99
Error	9	41.404	4.600			
Total	15	211.750				

*highly significant coefficient variation: 9.04%

Appendix Table 9. Computed marketable yield (t/ha)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	61.0	55.4	29.6	46.0	192.0	48.00
T_2	46.6	38.1	34.6	48.0	167.3	41.35
T_3	51.0	39.0	33.0	37.2	160.2	40.50
T_4	31.0	43.4	43.6	31.0	149.0	37.25

ANOVA

Source	Degrees of Freedom	Sum of Square	Mean Squares	F Value	0.05	0.01
Replication	3	324.847	108.282			
Factor A	3	248.817	82.939	1.06ns	3.86	6.99
Error	9	703.581	78.176			
Total	15	1277.244				

*ns=not significant coefficient variation: 21.16%