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Effects of Irrigation and Different Mulches on Yield of Profitability of Cauliflower

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Abstract: A field experiment on cauliflower (var. Rupa) was conducted in two consecutive years from November 2000 to March 2002 in sandy clay loam soil at the Agricultural Research Station, Raikhali, Rangamati Hill District to observe the effect of irrigation and mulch materials on its yield, yield attributes and profitability. Twenty combinations of treatments consisting of four levels of irrigation (no irrigation = control, irrigation at 7, irrigation at 14 and irrigation at 21 days interval) and five levels of mulching (non mulch (control), black polythene mulch, rice straw mulch, sun grass mulch and mango leaves' mulch) were used for this trial. Irrigation at 7 days interval and mulching with black polythene independently as well as in combination produced maximum values for yield attributes and marketable yield of cauliflower. The highest curd yields of 30.38 and 29.40 t ha^{-1} were obtained from 7 days irrigation interval with black polythene mulch in 2000-01 and 2001-02, respectively. The lowest curd yields of 10.50 and 10.04 t ha^{-1} were obtained from without irrigation and mulching in 2000-01 and 2001-02, respectively. Seven days interval irrigation and mulching with forest leaves (mango leaves) in combination gave the highest benefit cost ratio (6.51) closely followed by 14 days interval irrigation with the same mulch (6.48). But maximum marginal rate of return (1156.89%) was recorded from the combination of 14 days interval irrigation and mulching by mango leaves followed by irrigation at 21 days interval with the same type of mulch (936.92%).

Key words: Irrigation, mulch, cauliflower, yield, profitability

INTRODUCTION

Cauliflower, *Brassica oleracia* var. *botrytis* is a nutritious, delicious and important vegetable crop grown in Bangladesh (Razzaque *et al*., 2000). The yield of crop can be increased through breeding and different cultural practices of which irrigation and mulching are the two main ways to increase the yield of cauliflower (AVRDC, 1990). The crop is grown in Bangladesh during winter when there is low precipitation and high evapotranspiration. Crop cultivation during this dry period usually requires irrigation. Cauliflower being a shallow rooted crop, requires frequent irrigation to keep the plant vigorous. Interval moister stress causes reduction in cell division and cell elongation and hence plant growth was stunted (Tisadale *et al*., 1984). Studies of various workers indicated that frequent irrigation gave the higher yields of curd (Islam *et al*., 1996; Gomes *et al*., 2000). Non-judicious irrigation not only reduces the efficiency of fertilizer and water use but also reduces the yield of Cole crop (Rahman *et al*., 1988).

There are different kinds of mulches used in the field, a) organic mulches (rice straw, dry grass, forest leaf etc) and b) plastic mulches (transparent, black or yellow) depending on the purpose of the mulch (Rudich, 1979). Generally, mulching helps to maintain uniform temperature, controls weed and the draining of fertilizers, conserves soil moisture and improves irrigation efficiency (AVRDC, 1990; Benoit and Ceustermans, 1996). Organic mulches not only increase the yield but also add more organic matter and improve soil fertility as well as quality (Rao and Pathak, 1998). Maximum return from cauliflower cultivation was obtained with mango leaves as mulch (Singh and Mishra, 1975). Black plastic mulch lowers the soil temperature by preventing sunlight from reaching the soil surface and heating it and thus conserves soil moisture (AVRDC, 1990). It also controls weeds more successfully than other inorganic as well as organic mulches (Bonanno, 1996). An increase in average head weight of lettuce was obtained when black polyethylene mulch was used (Poll, 1 996). The information on the judicious use of irrigation water to different mulch

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materials on cauliflower production is scanty in Bangladesh. Therefore, the present study was undertaken to study the effect of irrigation and mulches on the yield, yield attributes and profitability of cauliflower.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Research Station, Raikhali and Rangamati Hill district during two consecutive Rabi seasons of 2000-01 and 2001-02). The treatment consisted of four levels of irrigation (T_0 = no irrigation (control), T_1 = Irrigation at 7 days interval, T_2 = Irrigation at 14 days interval and T_3 = Irrigation at 21 days interval) and five levels of mulch (M_0 = non mulch (control), M_1 = Black polythene, M_2 = Rice straw, M_3 = Dried Sun grass and M_4 = Dried mango leaves). The experiment having combinations of irrigation in main plots and mulch levels in sub plots was conducted in split-plot design with three replications. Seedlings of thirty days old were transplanted on 7 November 2000 and 13 November 2001 at a spacing of 60×50 cm. The crops were harvested on 6 February 2001 and 15 February 2002 in 2000-01 and 2001-02, respectively. The unit plot size was 4×2.4 m. The cauliflower variety was Rupa (BARI Fulkapi 1). Irrigation was done by boarder method. The irrigation water was applied during the growing period according to the irrigation scheduling (7, 14 and 21 days interval). Irrigation was started at 15 days after transplanting. For proper seedling establishment water was given for seven days after transplanting by a water can. Mulch materials at the rate of 5 t ha^{-1} were placed just after the establishment of the seedlings (15 days after transplanting) except black polythene. Black polythene was placed before transplanting of the seedlings. Manures and fertilizers were applied at the rate of 10 tons well-decomposed cowdung, 150 kg N, 70 kg P_2O_5 and 110 kg K_2O. The N, P_2O_5 and K_2O were applied in the form of Urea, TSP and MP. The entire amount of cowdung and TSP and half of urea and MP were applied during final land preparation. The remaining urea and MP were applied in two equal splits at 30 and 45 days after transplanting. Other cultural practices were adopted as per recommendation given in the package of practices. The data on plant height, number of leaves per plant, size of the biggest leaf, curd compactness (angle between center of the curd stalk and the point of attachment of last buttons in the stalk) were recorded treatment wise from 10 plants of the plot. Four harvestings were taken and marketable yield was recorded at each harvest per plot in kilograms and it was then converted into yield per hectare in tons. Data on curd diameter and individual marketable curd weight were recorded from 10 plants per plot. Besides, economical analysis was done on the basis of variable cost (land preparation, seedling, fertilization, labour, irrigation, mulch materials etc.), gross return, gross margin and BCR of the two years' mean data. Economic evaluation of different irrigation and mulch combinations was obtained through dominance analysis followed by marginal analysis of the cost undominated treatments as suggested by Elias and Karim (1984). Marginal Rate of Return (MRR) was calculated by the following equation:

$$MRR = \frac{MGM}{MVC} \times 100$$

where, MGM = Marginal gross margin
MVC = Marginal variable cost

RESULTS AND DISCUSSION

Effects of irrigation: Irrigation levels had significant effect on all yield parameters and yield of cauliflower. The highest values for all the yield parameters were recorded from T_1 (7 days interval irrigation) during both the years followed by T_2 (14 days interval irrigation) (Table 1). The treatment T_0 where irrigation was not done showed poor results in respect of all yield attributes in both the years compared to T_1, T_2 and T_3 treatments. In the year of 2000-01 significantly the highest marketable curd yield was obtained in T_1 (27.54 t ha^{-1}) followed by T_2 (24.57 t ha^{-1}) and the lowest marketable curd yield of 10.04 t ha^{-1} was obtained in T_0. Similar trend also obtained in case of yield in 2001-02. The average of two years' result showed that higher curd yield (26.97 t ha^{-1}) was observed in treatment T_1 due to higher yield attributes and frequency of irrigation water. Frequent watering to the soil especially during the early growth stages of the crop prevented water stress and kept the soil in available moisture condition that helped to improve plant growth and ultimately the curd yield increased. These findings are in agreement with Islam *et al.* (1990) and Gomes *et al.* (2000). Islam *et al.* (1990) reported that maximum curd yield of cauliflower was obtained with 18.2-24.2 cm water from the 10 days interval irrigation whereas Gomes *et al.* (2000) got the highest curd yield of broccoli from 12 days interval irrigation.

Effects of mulch: Yield parameters and different mulch materials (Table 1) significantly influenced yields. Significantly highest values for all the parameters except curd compactness were recorded from the treatment M_1 (black polythene mulch) during both the years. The M_3 treatment (sun grass mulch) gave statistically similar results to those of M_1 treatment in respect of plant height,

Table 1: Effect of irrigation and mulch on the yield and yield contributing attributes of cauliflower

	Plant height (cm)		No. of leaves/plant		Size of the biggest leaf (cm^2)		Curd compactness (angle)	
Treatments	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Irrigation								
T_0	40.05d	39.91d	17.00d	16.89d	489.00d	475.30d	88.4c	87.30c
T_1	58.98a	56.56a	27.57a	27.29a	675.60a	641.79a1	04.3a	103.2a
T_2	54.92b	52.67b	24.43b	24.18b	602.96b	572.78b	99.6b	98.6b
T_3	51.10c	49.00c	19.94c	19.26c	541.40c	514.30c	88.5c	87.61c
CV (%)	10.53	9.87	6.58	7.42	10.89	10.65	8.96	9.36
Mulch								
M_0	52.17c	50.00c	21.58d	21.36d	638.38c	606.43c	99.9c	98.97c
M_1	57.05a	54.71a	26.02a	25.75a	707.63a	672.22a	106.5a	105.43a
M_2	54.25b	52.02b	22.70c	22.47c	673.70b	639.98b	104.4b	100.35b
M_3	56.74a	54.41a	25.62a	25.36a	703.04a	667.85a	107.3a	106.22a
M_4	54.73b	52.48b	23.26b	23.00b	658.32b	625.38b	100.2c	99.20c
CV (%)	10.53	9.87	6.58	7.42	10.89	10.65	8.96	9.36

	Curd diameter (cm)		Marketable curd weight (g/plant)		Marketable curd yield (t ha^{-1})	
Treatments	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Irrigation						
T_0	12.41d	12.10d	450.20d	429.13d	10.10d	10.04d
T_1	193.33a	18.72a	1118.64a	1091.00a	27.54a	26.40a
T_2	16.79b	16.26b	1010.00b	985.05b	24.57b	23.56b
T_3	14.59c	14.13c	821.97c	801.66c	19.87c	19.06c
CV (%)	7.32	7.21	9.85	9.54	9.87	9.37
Mulch						
M_0	15.23e	14.75c	758.59e	739.46e	15.47e	14.70e
M_1	18.45a	17.87a	1089.63a	1062.59a	26.98a	25.88a
M_2	16.09d	15.58b	942.68d	919.71d	22.67d	21.86d
M_3	18.00b	17.43a	1074.14b	1047.47b	26.33b	24.93b
M_4	16.48c	15.96b	982.00c	957.74c	23.83c	22.84c
CV (%)	7.32	7.21	9.85	9.54	9.87	9.37

Means having same letter(s) are not significantly different at 5% level of probability by DMRT, Y_1 = 2000-01, Y_2 = 2001-02, T_0 = No irrigation, T_1 = 7 days interval irrigation, T_2 = 14 days interval irrigation, T_3 = 21 days interval irrigation, M_0 = No mulch, M_1 = Black polythene mulch, M_2 = Rice straw mulch, M_3 = Sun grass mulch and M_4 = Mango leaves mulch

Table 2: Interaction effect of irrigation and mulch on the yield and yield attributes of cauliflower

Treatments		Plant height (cm)		No. of leaves/plant		Size of the biggest leaf (cm^2)		Curd compactness (angle)	
Irrigation	Mulching	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_0	M_0	45.10f	45.01f	18.0h	17.1h	512.1k	510.5ll	65.50k	67.05i
	M_1	45.23f	43.70g	20.83f	20.42f	654.17f	643.27h	76.74g	75.97f
	M_2	44.32f	42.82g	18.33h	17.96h	582.21j	572.51jk	68.29k	66.09k
	M_3	45.20f	43.67g	20.34fg	19.44g	588.03j	578.23jk	75.80g	73.36gh
	M_4	45.10f	43.50g	18.71gh	18.34gh	564.50j	555.10k	69.73k	67.49i
T_1	M_0	51.69d	50.08d	25.47c	25.21d	733.59b	718.18c	96.40e	94.94c
	M_1	59.88a	57.73a	30.13a	29.82a	800.82a	784.00a	113.94a	112.80a
	M_2	55.18b	53.47bc	25.92c	25.66cd	729.79b	714.46c	97.72d	96.74c
	M_3	58.98a	57.15a	29.82a	29.52a	791.85a	775.21b	112.81a	111.68a
	M_4	55.83bc	54.09b	26.80b	26.50b	737.10b	721.60c	102.08b	101.06b
T_2	M_0	49.20e	47.48ef	21.44e	21.00f	627.44g	614.26h	80.47g	79.66e
	M_1	54.63c	52.93bc	26.90b	26.60b	718.08c	702.90d	101.38b	100.36bc
	M_2	50.71d	50.10d	23.66d	23.42l	646.15f	632.43g	89.64f	88.74d
	M_3	54.11c	52.43c	26.49b	26.22b	712.16c	697.04d	99.98c	98.98bc
	M_4	52.34d	50.72d	23.94d	23.70e	664.51e	650.54f	90.55f	89.64d
T_3	M_0	48.59e	47.09ef	18.13h	17.94h	594.38ij	581.89jk	67.96k	67.28h
	M_1	49.17e	47.50ef	21.05ef	20.84f	674.40d	663.17e	79.94g	79.14e
	M_2	48.45e	46.95ef	18.52gh	18.33gh	602.81hi	590.15ij	70.07i	69.37h
	M_3	49.40e	47.87e	20.56f	20.35f	610.45h	597.62i	78.32h	77.54f
	M_4	48.35e	46.50f	19.05g	18.86g	591.03j	580.00k	72.65i	71.92g
CV (%)		10.53	9.87	6.58	7.42	10.89	10.65	8.96	9.36

Table 2: Continued

Treatments		Curd diameter (cm)		Marketable curd weight (g/plant)		Marketable curd yield (t ha^{-1})	
Irrigation	Mulching	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_0	M_0	11.40l	11.01j	600.50l	550.00m	10.50l	10.05l
	M_1	13.34i	13.06h	700.30k	683.52k	12.70k	12.31j
	M_2	11.66l	11.36j	609.64l	594.66l	11.04jk	10.58k
	M_3	13.05j	12.72i	682.79kl	666.02k	12.36j	11.84k
	M_4	12.00k	11.70ij	635.00l	619.40l	11.74jk	11.24k
T_1	M_0	17.70e	16.96d	825.00h	800.80h	19.85g	19.15g
	M_1	21.14a	20.69a	1226.94a	1196.78a	30.38a	29.40a
	M_2	18.13d	17.62d	1045.95c	1020.24d	25.91c	25.00c
	M_3	20.93a	20.49a	1210.30a	1180.55a	30.00a	29.00a
	M_4	18.94b	18.54b	1084.90b	1058.23bc	26.88b	26.02b
T_2	M_0	14.93g	14.62f	725.00i	710.0l	15.06j	15.06i
	M_1	18.81bc	18.41bc	1087.00b	1060.28b	26.92b	26.06b
	M_2	16.63f	16.28e	949.00f	9925.67g	23.50e	22.75e
	M_3	18.55c	18.16c	1074.00b	1047.60bc	26.61b	25.76b
	M_4	16.80f	16.45e	968.95e	945.00e	24.00d	23.23d
T_3	M_0	12.66j	12.39i	700.35j	700.10kl	12.65j	12.35j
	M_1	14.83g	14.52fg	854.57g	833.56hi	21.18f	20.50f
	M_2	13.00j	12.72i	746.95j	728.59k	18.50i	17.91h
	M_3	14.53h	14.22g	839.39h	818.76i	20.79f	20.12f
	M_4	13.48i	13.20h	773.18i	754.18j	18.77h	18.17h
CV (%)		7.32	7.21	9.85	9.54	9.87	9.37

Means having same letter(s) in a column are not significantly different at 5% level of probability by DMRT, Y_1 = 2000-01, Y_2 = 2001-02, T_0 = No irrigation, T_1 = 7 days interval irrigation, T_3 = 14 days interval irrigation, T_3 = 21 days interval irrigation, M_0 = No mulch, M_1 = Black polythene mulch, M_2 = Rice straw mulch, M_3 = Sun grass mulch and M_4 = Mango leaves mulch

Table 3: Benefit cost analysis on cauliflower production in different levels of irrigation and mulch (Two years' average data)

Treatments		Average yield of cauliflower (t ha^{-1})	Gross return (000 Tk.)	Cost of production (000 Tk.)	Gross margin (000 Tk.)	Benefit-cost ratio (BCR)
Irrigation	Mulching					
T_0	M_0	10.27	82.16	19.96	62.20	4.11
	M_1	12.50	100.00	55.96	44.04	2.79
	M_2	10.81	86.48	29.96	56.52	3.89
	M_3	12.10	96.80	29.96	66.84	4.23
	M_4	11.49	91.92	24.96	66.96	4.68
T_1	M_0	19.50	156.00	27.50	128.50	5.67
	M_1	29.89	239.12	63.50	175.62	3.76
	M_2	25.45	203.60	37.50	166.01	5.43
	M_3	29.50	236.00	37.50	198.50	6.29
	M_4	26.45	211.60	32.50	179.10	6.51
T_2	M_0	15.10	120.80	24.16	96.64	5.00
	M_1	26.49	211.92	60.14	151.76	3.52
	M_2	23.13	185.04	34.16	150.88	5.42
	M_3	26.19	209.52	34.16	175.36	6.13
	M_4	23.61	188.88	29.16	159.64	6.48
T_3	M_0	12.50	100.00	21.76	78.24	4.59
	M_1	20.84	166.72	45.76	120.96	3.64
	M_2	18.20	145.60	31.76	113.84	4.58
	M_3	20.46	163.68	31.76	131.92	5.15
	M_4	18.47	147.76	26.76	121.00	5.52

Cost of ploughing = At the rate of Tk. 400/ha/tillage, 7 days interval irrigation cost (T_1) = Tk. 7,540/ha, 14 days interval irrigation cost (T_2) = Tk. 4,200/ha, 21 days interval irrigation cost (T_3) = Tk. 1,800/ha, Black polythene (M_1) = Tk, 36000.00 (2000 meter, at the rate of Tk. 18/meter), Rice straw (M_2) = Tk. 10,000/ha, Sun grass (M_3) = Tk. 10,000/ha, Mango leaves (M_4) = Tk. 5,000/ha, Hired labour = at the rate of Tk. 70/man-days, Seedling price = at the rate of Tk. 200/1000, Urea = at the rate of Tk.6/kg, TSP = at the rate of Tk. 13.50/kg, MP = at the rate of Tk. 8/kg, Product price (curd) = at the rate of Tk. 8/kg, Fixed cost = Tk. 19.96 thousand/ha

number of leaves/plant, size of the biggest leaf and curd compactness during both the years and curd diameter only in 2001-02. But the poorest results were obtained from the non-mulch treated plots (M_0). Significantly the highest marketable curd yield of 26.98 t ha^{-1} was obtained from the treatment M_1 and the lowest yield of 15.47 t ha^{-1} from M_0 (control) treatment in 2000-01. Similar results were also found in 2001-02, the maximum yield (25.88 t ha^{-1}) from M_1 and the lowest yield (14.70 t ha^{-1}) from M_0 treatment. All the mulch materials showed better performances over control treatment because of better soil environment created by mulching. The two years' average data showed that the M_1 treatment produced the maximum yield of cauliflower (26.43 t ha^{-1}) followed by M_3 treatment

Table 4: Marginal rate of return analysis of different levels of irrigation and mulch on cauliflower production (two years' average data)

Cost undominated treatments	Gross margin (Tk/ha)	Marginal gross margin (Tk/ha)	Total variable cost (Tk/ha)	Marginal variable cost (Tk/ha)	Marginal rate of return (MRR) (%)
T_1M_3	198460	23140	17540	3340	692.81
T_2M_3	175320	(-) 3740	14200	1660	(-) 225.30
T_1M_4	179060	19390	12540	5740	339.02
T_2M_4	159640	38640	9200	3340	1156.89
T_3M_4	121000	24360	6800	2600	936.92
T_2M_0	966400	18400	4200	2400	766.67
T_3M_0	782400	16040	1800	1800	891.11
T_0M_0	622000	-	-	-	-

Total variable cost indicates the cost of irrigation and mulching, T_0 = No irrigation, T_1 = 7 days interval irrigation, T_3 = 14 days interval irrigation, T_3 = 21 days interval irrigation, M_0 = No mulch, M_1 = Black polythene mulch, M_2 = Rice straw mulch, M_3 = Sun grass mulch and M_4 = Mango leaves mulch

(25.65 t ha^{-1}) and M_4 treatment (23.33 t ha^{-1}). These results are in perfect agreement with Salim (1994) who found the highest curd yield of cauliflower (22.8 t ha^{-1}) using black polythene mulch but got only 18.04 tones curd per hectare from no mulched plots. The increase in curd yield due to black polythene mulching might occur from better moisture utilization by checking evaporation loss and fall of soil temperature during winter and lesser competition of weeds. Similar results were also reported by Gunadi and Suwandi (1988), Saifullah *et al.* (1996) and Pessala (1994) in tomato, cabbage and kohlrabi, respectively.

Combined effect of irrigation and mulch: The treatment combinations of T_1M_1 and T_1M_3 gave the statistical identical results in respect of yield and yield attributes with an exception of the size of the biggest leaf in 2001-02 where yields showed significantly higher than T_1M_2 and T_1M_4 in both the years (Table 2). During the year of 2000-01, 7 days interval irrigation with black polythene mulch (T_1M_1) produced the highest marketable curd yield of 30.38 t ha^{-1} closely followed by T_1M_3 (30.00 t ha^{-1}) while no irrigation and no mulch combination (T_0M_0) produced the lowest yield of 10.05 t ha^{-1}. Similar trends were also observed in 2001-02. The above discussion revealed that black polythene and sun grass mulch performed better compared to other two mulch materials irrespective of irrigation treatments.

Economics: Table 3 shows that the highest gross return (Tk. 39.12 thousand/ha) and gross margin (Tk. 198.50 thousand/ha) were recorded from T_1M_1 and T_1M_3, respectively. But maximum Benefit Cost Ratio (BCR) was found from 7 days irrigation interval with mango leaves' mulch (T_1M_4) (6.51) closely followed by T_2M_4 (6.48) due to lower cost involvement in mango leaves' mulch. The variations in BCR were less and seemed to be very close among some of the treatments. Therefore, Marginal Rate of Return (MRR) analysis was calculated. For marginal rate of return analysis (Table 4), by arranging the gross margin with the total variable cost for all the treatments, it was observed that the treatments T_1M_3, T_2M_3, T_1M_4, T_2M_4, T_3M_4, T_2M_0, T_3M_0 and T_0M_0 were found cost undominated treatments and the rest as cost dominated treatments. From Table 4, it revealed that the maximum MRR (1156.89%) was obtained from T_2M_4 combination followed by T_3M_4 (936.92%). It signifies that if someone irrigates cauliflower at 14 or 21 days interval with mango leaves' mulch (T_1M_4), it would maximize the rate of return to capital. This result is in perfect agreement with Sing and Mishra (1975).

Based on the above discussion, it could be inferred that proper irrigation intervals (14 or 21 days) with forest leaves' (mango leaves) mulch could be profitable for cauliflower production.

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