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Enhancement of farm income in vegetable cultivation through introduction of plastic mulching in foothills of Eastern Himalaya

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ABSTRACT

The field experiments were carried out in collaboration with different FPOs' to investigate the effectiveness of polythene mulch on growth, yield and economic return of winter season vegetables under multi-locational trial in Cooch Behar and Alipurduar districts of West Bengal during 2020-21 and 2021-22 as one of the activities under ICAR-National Agricultural Science Fund Project entitled Development and validation of need based technology delivery model through Farmers Producers Organization for Eastern Region of India. The results revealed that changes in location have significant effect on the performance of winter season vegetables. Again, presence of polythene mulch emerged superior in terms of higher fruit number and estimated fruit yield in tomato and capsicum; head weight in sprouting broccoli and number of cloves and clove weight in garlic. The economic study showed that the highest expenditure for cultivation was observed for garlic without polythene mulch while the maximum gross returns and benefit:cost ratio were observed in capsicum followed by tomato under polythene mulch treatment. The findings suggested that adoption of polythene mulch during cultivation of winter season vegetables will increase the crop growth and yield and subsequently lead to higher economic return to the farmers from vegetable cultivation in the northern parts of West Bengal.

***Keywords*:** Economic return, growth, polythene mulch, winter season vegetables and yield

The winter season vegetables, namely tomato, capsicum, sprouting broccoli and garlic occupy considerable area in Cooch Behar and Alipuduar districts of West Bengal. Traditional cultivation practices failed to achieve the desirable yield and economic return from vegetable cultivation as compare to developed countries. Adoption of polythene mulch is becoming popular among the farmers of the country due to better soil moisture conservation, reduction in weed density, prevention of soil and water erosion, minimizes fertilizer loss, maintenance of soil temperature, promotion of microbial activity in the rhizosphere and reduction in pest and disease infestation of crop, thus provide better growing environment for the optimum growth of the crop (Abbasi *et al*., 2002; Manna *et al*., 2005 and Kumar *et al*., 2019). Several research findings explored the differences and change in vegetable production using plastic mulch in India and other countries around the world. The cropping duration of tropical origin has also been increased in presence of plastic mulch material (Lamont, 2005). Depending upon the purpose of use, the plastic mulch may be of transparent/ black/ red/ yellow or others (Rudich *et al.*, 1978). Singh *et al*. (2014) reported 33.34% higher marketable fruit yield under black plastic mulch over no mulch treatment on the same crop. Islam *et al*. (2021) reported that capsicum with silver cover black polythene mulch produced 45% higher number of fruits, 60% more fruit weight and 134% higher fruit yield plant^{-1} over no-mulch treatment. Paul *et al*. (2013) reported that capsicum with polythene mulch produced 13% high number of fruits, 14% more fruit weight and 14% high fruit yield plant^{-1} over no mulch treatment. Islam *et al*. (2021) opined that broccoli with silver cover black polythene mulch produced 25% high number of heads, 29% more marketable head yield plant^{-1} over no-mulch treatment. Shan *et al*. (2022) reported that polythene mulch produced 19% higher head weight in broccoli over no mulch treatment. Kwon *et al*. (2011) showed that polythene mulch produced 16% higher number of cloves and 32% higher bulb weight in garlic over no mulch treatment. Anwar *et al*. (2020) reported that 45% higher bulb weight over no mulch treatment in garlic. Coochbehar and Alipurduar are the leading vegetable growing districts of West Bengal. But use of mulch material as intercultural practices is rare among the vegetable growers. Lack of knowledge and awareness prevent the farmers to reap the benefit of polythene mulches in vegetable

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cultivation. Keeping in these views, an experiment was designed and conducted in the selected FPO's farmer's field to study the influence of polythene mulch on different winter season vegetables (tomato, capsicum, broccoli and garlic) under multi-locational trial in foot hills (Cooch Behar and Alipurduar districts) of eastern Himalayan region of West Bengal, India.

MATERIALS AND METHODS

The field experiments was conducted in the farmers' field of the 3 FPCs of Cooch Behar and Alipurduar districts for four different vegetable crops during the winter season of 2020-21 and 2021-22 as one of the activities under ICAR-National Agricultural Science Fund Project entitled 'Development and validation of need based technology delivery model through Farmers Producers Organization for Eastern Region of India'. The experiment was laid out in 2 factors Factorial Randomized Block Design with 5 replications. The first factor was location and 3 different FPCs were randomly selected from the exhaustively list of FPCs of the districts Cooch Behar and Alipurduar for each crop (Table 1). The second factor was plastic mulching, two different treatments viz. (B_1 - without plastic mulching) and (B_2 - with plastic mulch) were selected. The hybrid seeds of tomato (Syngenta 1057 F1), capsicum (Sanya F1), sprouting broccoli (Green Magic F1) and planting material of local garlic cultivar were supplied to the farmers for crop raising. Recommended agronomic practices were being followed for all the four crops. The beds in main field were prepared and covered with 25 gsm thick UV stabilized silver cover black polythene mulch sheet for B_2 treatments. Spacing of 100 cm x 75 cm, 60 cm x 60 cm, 60 cm x 45 cm and 20 cm x 10 cm were kept for tomato, capsicum, broccoli and garlic respectively. Observations were noted for different growth and yield traits of the studied crops. Economics of cultivation was worked out considering the cost involved in purchasing the production inputs and expenditure related to labour charges and transportation of harvested produce to the market. The GR (gross return), NR (net return) and B:C (benefit cost) ratio were calculated with standard practices. The harvested produces were marketed as per prevailing market rate (Table-2). The recorded observations were subjected to statistical analysis using Factorial Randomized Block Design through suitable statistical package.

RESULTS AND DISCUSSION

Mulching is one of the important agricultural practices in modern days and is gaining rapid popularity. The use of mulch sheet in vegetable cultivation is undergoing a radical change away from high input, non-renewable resources like plastic to high-residue-organic mulch like dry residue of cover crop. Several researchers reported white or aluminum reflective mulch as aphid repellent which spread different viral diseases. In other way, mulching can be a effective step forward to increase horticultural crop production in those regions having water scarce.

Growth and yield parameters of different winter season vegetables

Mulch helps in keeping vegetables or fruits clean from contacting the soil or spoilage free, reduces soil rot/ blossom end rot/ fruit cracking and produce smoother glossy fruits with fewer scars. Properly installed plastic mulch also reduces splashing dirt/soil onto the plants during rainfall, which reduces time at grading and sorting. The yield and biochemical composition of tomatoes/ muskmelons/ cucumbers/ eggplants were found to be enhanced (Gupta and Gupta, 1987) by using mulch. It provides a favorable environment for growth, health and vigour of plants, that helps in building more resistance to pest and disease attack. High moisture content and soil temperature increase root growth which leads to increase in overall plant growth. As a result of it, mulched plants generally grow and reach to harvestable maturity with more uniformity than the non-mulched (Bhardwaj *et al*., 2011). Lourduraj and his co-workers (1996) obtained number of laterals shoots (8.6 per plant) and highest plant height (81.5 cm) in tomato with the application of black LDPE mulch than the organic and no mulch. Warm season vegetables like, cucumbers/ muskmelons/ watermelons/ eggplant/ peppers generally respond well to mulching techniques in terms of earliness and higher productivity due to continuous maintenance of favorable temperatures through crop growing period. Black mulch with raised bed prior to planting will make the soil warm and promotes earlier growth, which usually leads to earlier harvest and higher yield (Tarara, 2000 and Lamont, 2005).

Tomato

In case of tomato significant differences were observed for plant height, fruit weight, number of fruits plant^{-1}, yield plant^{-1}, estimated yield ha^{-1} and harvest duration among the different FPC locations as well as between polythene mulch and no mulch treatment (Table 3). Polythene mulch plot recorded maximum plant height (153.64 cm), number of fruits plant^{-1} (122.40), fruit weight (80.23 gm), yield plant^{-1} (9.39 kg), harvest duration (91.47 days) and estimated yield ha^{-1} (115.17 tones) compared to no mulch plots (Table 3). Kundu *et al*. (2019) recorded highest yield 60.30 ton ha^{-1} and 58.70 ton ha^{-1} of tomato under poly mulches for the consecutive two year in their experiment at coastal part

Table 1: Location of FPCs selected for cultivation of different winter season vegetable crops

Crops	A1- FPC	A2- FPC	A3-FPC
Tomato	Falakata Krishi kalyan FPC, Paschim Jharbeltali, Alipurduar	Rabindra FPC, Mekliganj, Cooch behar	Thaneswar FPC, Gopalpur, Cooch Behar
Capsicum	JC FPC, Chilkirhat, Cooch Behar	Rabindra FPC, Mekliganj, Cooch behar	Falakata Krishi kalyan FPC, Paschim Jharbeltali, Alipurduar
Broccoli	Sabuj Mitra FC, Sahebganj, Dinhata, Cooch behar	Thaneswar FPC, Gopalpur, Cooch Behar	Bhumi Shakti FPC, Chat Singimari, Cooch behar
Garlic	Krishi Ratna FPC, Pundibari Cooch Behar	Bhumi Shakti FPC, Chat Singimari, Cooch behar	Thaneswar FPC, Gopalpur, Cooch Behar

Table 2: Selling price of different harvested produce in different FPC

Crops	A1- FPC		A2- FPC		A3- FPC	
	Without mulching	Mulching	Without mulching	Mulching	Without mulching	Mulching
Tomato	Rs. 13.00	Rs. 15.00	Rs. 12.00	Rs. 14.00	Rs. 12.00	Rs. 15.00
Capsicum	Rs. 48.00	Rs. 52.00	Rs. 48.00	Rs. 60.00	Rs. 48.00	Rs. 63.00
Broccoli	Rs. 14.00	Rs. 17.00	Rs. 15.00	Rs. 18.00	Rs. 14.00	Rs. 17.00
Garlic	Rs. 62.00	Rs. 70.00	Rs. 61.00	Rs. 69.00	Rs. 62.00	Rs. 72.00

Table 3: Performance of tomato under multilocational trial and mulch treatment

Treatment	Plant height	No. of fruit plant^{-1}	Fruit weight (g)	Yield plant^{-1} (Kg)	Duration of harvest	Estimated yield (t ha^{-1})
A1	136.33	112.90	71.62	8.28	76.70	130.06
A2	142.20	119.10	70.53	7.72	75.70	89.90
A3	136.67	106.90	73.65	7.55	79.10	87.28
SEm	0.53	0.99	0.79	0.16	1.43	2.02
CD (0.05)	1.56	2.93	2.36	0.46	N/A	6.00
B1	123.16	103.53	63.64	6.31	62.87	89.66
B2	153.64	122.40	80.23	9.39	91.47	115.17
SEm	0.43	0.81	0.65	0.13	1.16	1.65
CD (0.05)	1.28	2.39	1.93	0.38	3.46	4.90
A1B1	122.20	99.20	59.92	5.87	63.00	120.19
A1B2	150.46	126.60	83.32	10.70	90.40	139.93
A2B1	126.33	112.80	62.20	6.74	59.40	71.03
A2B2	158.06	125.40	78.86	8.70	92.00	108.76
A3B1	120.94	98.60	68.64	6.32	66.20	77.74
A3B2	152.40	115.20	80.23	8.78	92.00	96.82
SEm(±)	**0.74**	**1.40**	**1.12**	**0.22**	**2.02**	**2.86**
LSD (0.05)	**N/A**	**4.15**	**3.34**	**0.65**	**N/A**	**8.49**

of West Bengal. Devi *et al*. (2020) also reported maximum number of leaves, plant height, yield attributes in tomato planted in drip in combination with mulching. Among the different location Falakata Krishi kalyan FPC recorded the highest yield plant^{-1}, fruit weight, duration of harvest and estimated yield ha^{-1}, The Falakata Krishi kalyan FPC recorded 7%, and 9% higher fruit yield plant^{-1} in tomato over Rabindra FPC and Thaneswar FPC respectively. Among the interaction of location and mulch treatment, Falakata Krishi kalyan FPC with poly mulching (Table 3) produced highest number of fruit plant^{-1} (126.60), fruit weight (83.32gm), yield plant^{-1} (10.70kg) and estimated yield ha^{-1} (139.93 ton). The maximum duration of harvest of tomato fruits (92.00 days) was found for Thaneswar FPC in presence of polythene mulch. Results of the study conducted by

Table 4: Performance of capsicum under multilocational trial and mulch metrical

Treatment	Plant height	No. of fruit plant^{-1}	Fruit weight (g)	Yield plant^{-1} (Kg)	Duration of harvest	Estimated yield (t ha^{-1})
A1	39.28	11.40	74.80	0.99	51.30	15.26
A2	42.26	9.70	78.40	0.74	53.30	12.06
A3	43.75	9.40	82.10	0.79	54.70	12.86
SEm	0.35	0.38	0.93	0.03	0.78	0.46
CD (0.05)	1.05	1.13	2.77	0.09	2.33	1.37
B1	34.80	8.07	70.33	0.59	44.33	10.11
B2	48.72	12.27	86.53	1.09	61.87	16.68
SEm	0.29	0.31	0.76	0.02	0.64	0.38
CD (0.05)	0.85	0.44	2.26	0.07	1.90	1.11
A1B1	32.18	8.80	69.00	0.72	41.80	11.26
A1B2	46.37	14.00	80.60	1.26	60.80	19.25
A2B1	33.34	7.80	69.80	0.52	44.60	9.33
A2B2	51.18	11.60	87.00	0.97	62.00	14.79
A3B1	38.88	7.60	72.20	0.54	46.60	9.73
A3B2	48.61	11.20	92.00	1.03	62.80	15.98
SEm (±)	**0.50**	**0.54**	**1.32**	**0.04**	**1.11**	**0.65**
LSD (0.05)	**1.48**	**N/A**	**3.92**	**N/A**	**N/A**	**N/A**

Table 5: Performance of broccoli under multilocational trial and mulch metrical

Treatment	Plant height (cm)	Head weight (gm)	Yield plant^{-1} (kg)	Estimated yield (t ha^{-1})
A1	57.26	868.70	0.87	22.08
A2	53.82	553.50	0.55	21.46
A3	53.80	538.80	0.54	20.88
SEm	0.67	7.95	0.01	0.28
CD (0.05)	2.00	22.61	0.02	0.83
B1	50.91	584.73	0.59	18.25
B2	59.01	722.60	0.72	24.70
SEm	0.55	6.49	0.01	0.23
CD (0.05)	1.64	19.28	0.02	0.68
A1B1	54.68	767.00	0.77	17.96
A1B2	59.84	970.40	0.97	26.21
A2B1	50.24	494.80	0.50	18.44
A2B2	57.40	612.20	0.61	24.48
A3B1	47.80	492.40	0.49	18.36
A3B2	59.80	585.20	0.59	23.40
SEm(±)	**0.95**	**11.24**	**0.01**	**0.40**
LSD (0.05)	**2.83**	**33.38**	**0.03**	**1.18**

Rao *et al*. (2016) reported higher number of flowers per cluster, fruit weight, plant height and yield in red mulch followed by black and silver colored plastic mulch compared to organic mulch and control. All the colored mulching treatments had significantly more marketable yield of tomato, while compared to the organic mulch and control. Marketable yield enhanced by 64.54% in red color mulched tomato followed by 57.45 % in black, 45.40% in silver and 21.98% in organic mulched crop over control.

Capsicum

In case of capsicum, significant differences were observed for plant height, fruit weight, number of fruit plant^{-1}, harvest duration, yield plant^{-1}, and estimated yield ha^{-1}, between different FPC location and presence of mulch metrical. Among the different FPC locations, the highest fruit yield plant^{-1}, minimum duration of harvest and estimated yield ha^{-1} were observed in JC FPC, Chilkirhat. Again maximum plant height (48.72),

Table 6: Performance of garlic under multilocational trial and mulch metrical

Treatment	Plant height (cm)	Fresh clove weight (g)	Dry clove weight (g)	No. of clovelet	Clove diameter (mm)	Estimated yield (t ha^{-1})
A1	43.57	35.04	26.92	27.30	12.97	17.31
A2	46.50	34.12	22.94	31.10	13.20	15.23
A3	49.33	35.71	29.13	25.50	12.98	14.26
SEm(±)	**0.25**	**0.27**	**0.20**	**0.26**	**0.18**	**0.18**
LSD (0.05)	**0.73**	**0.80**	**0.61**	**0.79**	**N/A**	**0.53**
B1	40.27	29.48	21.61	25.20	11.84	11.64
B2	52.66	40.44	31.05	30.73	14.26	19.56
SEm(±)	**0.20**	**0.22**	**0.16**	**0.21**	**0.14**	**0.14**
LSD (0.05)	**0.60**	**0.65**	**0.50**	**0.64**	**0.43**	**0.43**
A1B1	37.90	29.96	23.47	25.40	12.22	11.98
A1B2	49.24	40.11	30.37	29.20	13.72	22.64
A2B1	40.26	29.93	19.57	27.00	11.82	11.22
A2B2	52.74	38.31	26.32	35.20	14.58	19.23
A3B1	42.66	28.53	21.78	23.20	11.48	11.71
A3B2	56.00	42.90	36.47	27.80	14.48	16.80
SEm(±)	**0.35**	**0.38**	**0.29**	**0.37**	**0.25**	**0.25**
LSD (0.05)	**1.04**	**1.13**	**0.86**	**1.12**	**0.76**	**0.75**

number of fruit plant^{-1} (12.26), fruit weight (86.53 gm), yield plant^{-1} (1.08), harvest duration (61.86) and estimated yield ha^{-1} (16.67) were recorded in mulching plots. (Table 4). Lodhi *et al*. (2019) reported, the treatment (200 kg N ha^{-1}, 120 kg P_2O_5 ha^{-1}) and paddy straw mulch (@ 7 t ha^{-1}) to be the ideal in terms of fruit yield plant^{-1} (739.31g), fruit yield plot^{-1} (12.67 kg), and fruit yield ha^{-1} (21.12 t ha^{-1}) for bell pepper in West Bengal.

The interaction effect showed that among the location and mulching combination treatment combination, JC FPC, Chilkirhat with polythene mulch produced highest number of fruit plant^{-1} (14.00), fruit yield plant^{-1} (1.26 kg) and estimated yield ha^{-1} (19.25 ton). However A_3B_2 treatment showed the maximum fruit weight (92gm) and duration of harvest (62.80 days) of capsicum fruits. Debbarma and his co-workers (2019) reported some morphological traits like plant height, dry and fresh weight of plant and root and fruit attributes such as total number of fruits per plant, average weight of fruits, fruit diameter and length, lateral and polar circumference of fruit and total yield were significantly increased by drip irrigation alone as well as in conjunction with black plastic mulch. As per research findings conducted by Kumari and co-workers (2021), capsicum cultivation under silver colored plastic mulch not only reduces irrigation water usage but also enhanced yield, crop growth and water productivity at reduced level of irrigation (80% ETC) in the naturally ventilated greenhouse.

Sprouting broccoli

Results on performance of broccoli showed that location and mulching have significant effect on plant height, head weight, and estimated head yield. Among different location, Sabuj Mitra FC, Sahebganj recorded maximum plant height (57.26cm), highest head weight (866.70gm), and maximum estimated head yield (22.08 ton). Among the mulching treatments, broccoli raised with polythene mulch recorded maximum plant height (59.01 cm), highest head weight (722.60 kg) and subsequently maximum estimated head yield (24.70 t ha^{-1}). Results on interaction of location and mulching revealed that Sabuj Mitra FC, Sahebganj in combination with poly mulching recorded the maximum plant height (59.84 cm), highest head weight (970.40 gm) and subsequently highest estimated head yield ha^{-1} (26.21 ton ha^{-1}). Presence of mulch material recorded 27%, higher head weight of broccoli in Sabuj Mitra FC, Sahebganj. Again presence of poly mulching material recorded 24% and 19% higher head weight in Thaneswar FPC and Bhumi Shakti FPC respectively. Mohammed *et al*. (2016) recorded higher plant height, leaves number plant^{-1}, leaf area, number of branches per plant in broccoli of mulching with black polyethylene as compared to control. Thentu et al (2016) also reported highest plant height (71.90 cm), plant spread (92.25 cm) and number of leaves plant-1(38.51) with black polythene mulch treatment in broccoli, which

Table 6: Economics of cultivation of different winter season vegetables (Per ha)

Crop name	FPC location	Crop yield		Gross return (`)		Cost of cultivation (`)		Net return (`)		Benefit Cost Ratio (`)	
		Without Mulching (ton ha^{-1})	Mulching	Without Mulching	Mulching	Without Mulching	Mulching	Without Mulching	Mulching	Without Mulching	Mulching
Tomato	A1	88	112	1144000	1680000	225000	180000	919000	1500000	4.08	8.33
	A2	71.03	108.76	852360	1522640	210000	180000	642360	1342640	3.06	7.46
	A3	77.74	96.82	932880	1452300	204990	189000	727890	1263300	3.55	6.68
Capsicum	A1	11.26	17.8	540480	925600	120000	105000	420480	820600	3.50	7.82
	A2	9.33	14.79	447840	887400	110000	93000	337840	794400	3.07	8.54
	A3	9.73	15.98	467040	846940	105000	87500	362040	759440	3.45	8.68
Broccoli	A1	17.96	26.2	251440	445400	105000	84000	146440	361400	1.39	4.30
	A2	18.44	24.48	276600	440640	135000	120000	141600	320640	1.05	2.67
	A3	18.36	23.4	257040	397800	112000	99500	145040	298300	1.30	3.00
Garlic	A1	11.98	22.64	742760	1584800	273000	357000	469760	1227800	1.72	3.44
	A2	11.22	19.23	684420	1326870	291000	375000	393420	951870	1.35	2.54
	A3	11.71	16.8	726020	1209600	216000	300000	510020	909600	2.36	3.03

was superior to paddy straw mulch @ 5 t ha^{-1} and no mulch (control). Singh and Kumar (2017) conducted an experiment on broccoli by using black, silver and no mulch and observed maximum number of leaves per plant (47) and highest plant height (78.6 cm) in black plastic mulch. Patle *et al*. (2018) studied the effect of mulching and irrigation on plant growth attributes of broccoli and recorded maximum number of leaves plant^{-1} in mulched plot of drip and furrow irrigation. Number of leaves per plant, stem diameter and plant height were more under both levels of mulching and irrigation. Results revealed that the use of black polythene mulch sheet with wider spacing (45 x 60 cm) to be most advantageous in increasing the vegetative growth and quality attributes of sprouting broccoli while, narrow spacing (45 cm x 30 cm) with black polythene mulch results the higher yield of sprouting broccoli under Punjab conditions in terms of different growth, yield and biochemical traits (Kaur *et al*., 2021).

Garlic

Climate change affects a vast range of agricultural crop cultivation and garlic also comes within this list. Appropriate & sustainable technology needs to be developed or modified to get good quality planting materials and yield. Mulching avoids direct heat and manage the soil microclimate. Perhaps it stabilizes the soil temperature and enhances plant growth and yield (Dinda *et al.*, 2020). The data recorded on garlic revealed that both location and mulching material played significant role on growth and yield performance. Krishi Ratna FPC, Pundibari, recorded highest estimated yield (17.31t ha^{-1}) but low clove diameter and weight. Among the mulching treatment, presence of mulching showed significant effect and recorded 27% higher fresh clove weight and subsequently 41% higher estimated yield over no mulch treatment. The interaction effect showed that Thaneswar FPC, Gopalpur, in presence of polythene mulch recorded maximum plant height (56cm), highest fresh clove weight (42.90g) and maximum dry clove weight (36.47g) and subsequently highest estimated yield ha^{-1} (21.80 ton ha^{-1}). Haque *et al*. (2003) recorded the tallest plant height, leaves, number of roots plant^{-1}, higher length of bulb, fresh-dry weight of bulb and highest yield hectare^{-1} in water hyacinth mulched garlic. Number of cloves bulb^{-1} and bulb diameter were more in black-poly-ethylene mulch. Few garlic exotic cultivar resulted better than the local cultivar in some traits, viz. plant height, number of leaves, roots plant^{-1}, fresh-dry weight bulb and yield ha^{-1}. Total yield, vitamin C, TSS, flavonoids and bulb ash percent were affected by mulching. Although mulching could have improved

some quality traits in garlic but there is no effect on forcing (Mahdieh *et al*., 2012).

Economics of production

Economics of cultivation showed that among the 3 locations Falakata Krishi Kalyan FPC without polythene mulch treatment recorded maximum cost of cultivation for tomato, whereas JC FPC under polythene mulch recorded the highest cost of cultivation for capsicum. Among the different location, the maximum gross and net returns and subsequently highest benefit-cost ratio (8.33) was observed for mulched tomato under Falakata Krishi Kalyan FPC. The same FPC under polythene mulch recorded the maximum benefit-cost ratio (8.68) for capsicum. The Sabuj Mitra FC recorded the maximum benefit-cost ratio (4.30) for broccoli. In case of garlic Krishi Ratna FPC recorded the maximum benefit-cost ratio (3.44). The maximum cost of cultivation was observed for garlic without polythene mulch while the highest gross returns and benefit cost ratio were observed in capsicum followed by tomato under polythene mulch treatment. The maximum cost benefit ratio of Falakata Krishi Kalyan FPC might be due to higher yield of tomato in presence of polythene mulch which fetches higher price of the fresh tomato lead to higher returns and benefits. Besides different advantages like early harvesting, polyethylene film as a mulch can enhance plant growth and development as well as productivity and decrease evaporation, nutrient leaching loss, incidence of disease, pests occurrence and weed disturbance. It also improves fruit cleanliness, quality yield (Lamont, 1993; Farias-Larios and Orozco-Santos, 1997; Walters, 2003; Decoteau, 2007; Diaz-Perez *et al*.,2007; Hutton and Handley, 2007), gross return, net return and benefit : cost ratio of fruit and vegetable crops. Sutagundi (2000) reported that treatment of straw mulch recorded significantly higher net returns (Rs. 30,894 ha^{-1}) and benefit: cost ratio (1.80:1) compared to control in chilli.

CONCLUSION

The present study demonstrated that polythene mulch has a significant effect on the performance of different winter season vegetables. The presence of polythene mulch exhibited maximum benefit to tomato followed by capsicum, broccoli, and garlic. Winter vegetable cultivation can be made profitable, the availability of fresh vegetables can be extended and economic return can be enhanced by adopting polythene mulch as intercultural operation in the foot hills Eastern Himalayan region. However, immediately after harvest, the plastic mulch should be removed to avoid plastic degradation and soil pollution. Concerted efforts would be needed to promote the mulching based resource conservation technique in case of winter season vegetables to ensure the nutritional security and the return on investment among the FPC farmers in the foot hills of Eastern Himalaya.

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