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Economic feasibility of summer squash cultivation using low tunnel and black plastic mulch under *tarai* condition of Uttarakhand

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Abstract: A study was undertaken to investigate the economic feasibility of summer squash cultivation in *tarai* region of Uttarakhand during winter - spring season of 2013-14 and 2014-15. Among three transplanting dates, summer squash transplanted on 15th January was found to be best with respect to plant growth characters, total yield (373.50 q ha^{-1}), net return (`2,46,542 ha^{-1}) and benefit – cost ratio (2.72). Similarly, out of three low cost protected techniques evaluated along with control, low tunnel with black plastic mulch was observed as best with respect to plant growth characters, total yield (451.67 q ha^{-1}). Whereas, the maximum net return (`2,87,628 ha^{-1}) and benefit - cost ratio (3.58) was obtained in black plastic mulched plots. Out of 12 treatment combinations, summer squash planted on 15th January under black polyethylene mulch is most profitable in terms of getting maximum benefit - cost ratio of 4.41. Hence, the same is recommended for commercial cultivation of summer squash at farmer's field under *tarai* condition of Uttarakhand.

Keywords: *Cucurbita pepo*, Economics, Low tunnel, Plastic mulch, Summer squash

INTRODUCTION

Summer squash botanically known as *Cucurbita pepo* L., is one of the important quick growing and early yielding cucurbitaceous vegetable known by different names *viz., chappan-kaddu*, bush squash, common field pumpkin and vegetable marrow. Though in India, summer squash is not very popular but grown on a limited scale in Punjab, Delhi, Uttar Pradesh, Himachal Pradesh and hills of Uttarakhand. Summer squash performs well in mild weather conditions (16–27 °C), high relative humidity and bright sunshine are also ideal for squash cultivation. It is a compact bushy plant, in which the tendrils have been reduced in size and function. Ease in cultivation, quick growth, high yield and off season nature of crop lead to higher return per unit area under small and scattered land holding, thus attracting small and marginal vegetable growers toward its cultivation (Bhatt *et al.,* 2011).

Although the climatic conditions of *tarai* region of Uttarakhand is not suited for summer squash cultivation under open condition due to unfavourable temperature during growth period and shorter growing period. However, summer squash can be successfully cultivated under protected condition and fruits are sold at premium price as no other cucurbit is available in the market during that period. The major restrictive factor for summer squash cultivation in polyhouse is high cost of cultivation and poor economic condition of majority of farmers. However, summer squash cultivation can be made profitable for small and marginal farmers by modification of microclimatic condition using low cost protected cultivation techniques like plastic mulch and low tunnels. Mulching with plastic films modifies the soil temperature, moisture regimes and also control weeds (Singh *et. al.*, 2014). Amongst the different colored plastic film, mulching with black plastic has been found most efficient. Plastic low tunnels are miniature greenhouse-like structures approximately 60 to 100 cm high and 75 to 100 cm wide at the base and are erected with wire hoops or flexible wood or bamboo and covered with clear plastic. The tunnel warms the air surrounding the plants, using heat from the sun. The tunnels also protect plants from frost damage. Plastic low tunnels have great potential because they are cheap to construct, can be removed during the dry season (Lodhi *et al.,* 2013). Thus, considering the importance of summer squash as potential cucurbit of Uttarakhand and to diversify the vegetable cultivation, the present study was planned to find out the best low cost protected technology to make the summer squash cultivation a profitable business for small and marginal farmer of the region.

MATERIALS AND METHODS

The present study was carried out during winter - spring seasons of 2013-14 and 2014-15 at Vegetable Research Centre of G.B.P.U.A.&T., Pantnagar. The

experimental site lies in '*tarai*' plains of foot hills of Shivalik range of Himalayas at 29º N latitude, 79.29º E longitudes and an altitude at 243.8 m above mean sea level. The experiment was laid out in Two Factorial Randomized Block Design with four replications. The first factor include three transplanting dates *i.e.* 15th November (D_1), 15th December (D_2) and 15th January (D_3), whereas the second factor comprises of three low cost protected cultivation techniques *i.e.* black plastic mulch along with low tunnel (T_2), black plastic mulch (T_3) and low tunnel (T_4) were compared with un-mulched control (T_1). The experimental plot along with FYM @ 25 t/ha were supplied with fertilizers in the form of NPK @ 120, 100 and 80 kg ha^{-1}, respectively. The seedlings raised in polybags were transplanted at respective dates in the plot of 10 m × 1.00 m size at a spacing of 1.00 m × 0.75 m. The plots were mulched with black plastic film of 25 µ thickness one day before transplanting, where as low tunnels were erected day after transplanting using low cost bamboo sticks. Observations for growth and yield attributes were recorded using standard techniques. The economics of summer squash was worked out based on inputs and operational cost incurred since seed sowing to harvest of fruits including marketing. The data recorded for both the year was analyzed using statistical methods suggested by Panse and Sukhatme (1989) and pooled data is presented in tables.

RESULTS AND DISCUSSION

Growth and flowering: Data for various parameters presented in table 1 clearly revealed that different transplanting dates and low cost protected cultivation technologies like plastic mulch and low tunnels significantly affected the growth, flowering and yield of summer squash. Significantly wider plant spread of 103.00 cm was recorded in summer squash transplanted on 15th January in comparison to previously transplanted plants. Plastic mulch in combination with low tunnel increased the plant spread (112.80 cm) by the order of 81.93 % than open field cultivation whereas, low tunnel alone increases it by 70.16 % and plastic mulch alone increases it by the order of 42.50 % compared to control and all the low cost technology tested differed significantly than open field cultivation of summer squash. Interactive effect of both the factor *i.e.* low cost protected cultivation techniques and transplanting dates reveals significantly wider plant spread (122.00 cm) compared to the other treatments when summer squash was transplanted in low tunnel mulched with black plastic and transplanted on 15th January. Data pertaining to days to 50 % flowering (Table 1) reveals that earliest flowering *i.e.* minimum number of days to 50 % flowering (24.58) in summer squash was observed with 15th November planting followed by 15th January (30.83) and 15th December (35.08). Amongst the different low cost protected techniques, earliest flowering (26.56) were observed in plants mulched with black plastic grown under low tunnel plants and was *at par* with low tunnel (27.67), while it was significantly better than plants grown under black plastic film (30.78) and open cultivation (35.67) at probability of 0.05. On the other hand in the interaction effect of twelve treatment combinations reveals that minimum day taken to 50% flower formation (22.67) were noted in treatment combination comprises of low tunnel having black plastic mulch planted on 15th November. The increase in vegetative growth observed with 15th January planting was attributed to favourable moderate temperature as per crop requirement available for growth and development of summer squash, whereas lower temperature restrict the growth and development of early planted crop. Of the different low cost protected cultivations techniques evaluated during the study, use of low tunnel along with black plastic mulch recorded maximum vegetative growth and earliest flowering due to higher photosynthesis and other metabolic activity under favorable microclimate in terms of temperature around plant, soil and optimum soil moisture promoted better growth and early flowering. Salman *et al*. (1992) also observed that increase in soil temperature was observed under both plastic mulch and tunnel, and higher temperature promoted early vegetative growth and flowering compared to open field condition. Singh *et al*. (2005) reported better vegetative growth of plants under plastic films may be

Table 1. Effect of transplanting dates and low cost protected techniques on growth, flowering and yield of summer squash (Pooled data of both the year).

Treatments	Plant spread (cm)	Days to 50% flowering	Days to first harvest	Total crop duration (Days)	Total yield (q ha^{-1})
Dates of transplanting					
15th November (D_1)	94.66	25.58	46.17	101.50	284.72
15th December (D_2)	80.74	36.08	49.00	107.08	333.38
15th January (D_3)	103.00	31.83	49.00	84.33	373.51
CD at 5%	2.57	1.23	1.40	2.03	28.54
Low cost protected cultivation technique used					
Control (T_1)	62.00	36.67	58.55	91.44	106.32
Black plastic mulch and low tunnel (T_2)	112.80	27.56	43.22	103.00	451.67
Black mulch (T_3)	88.35	31.78	43.00	101.44	412.05
Low tunnel (T_4)	105.50	28.67	46.11	94.78	352.12
CD at 5%	2.23	1.26	1.21	1.85	25.60

Table 2. Interaction effect of transplanting dates and low cost protected techniques on growth, flowering and yield of summer squash (Pooled data of both the year).

Treatments combinations	Plant spread (cm)	Days to 50% flowering	Days to first harvest	Total crop duration (Days)	Total yield (q ha^{-1})
D_1 T_1	64.33	28.43	57.33	99.12	87.45
D_1 T_2	118.67	23.76	39.67	105.00	415.66
D_1 T_3	91.60	26.10	45.33	101.33	305.75
D1 T_4	104.30	24.33	42.33	102.72	320.05
D_2 T_1	55.00	42.35	52.25	105.33	80.56
D_2 T_2	101.35	31.16	49.00	111.76	495.32
D_2 T_3	74.30	38.75	36.67	111.35	395.35
D_2 T_4	93.60	32.67	52.00	107.00	352.32
D_3 T_1	68.33	39.33	59.00	82.16	150.97
D_3T_2	122.00	28.00	44.15	92.00	440.04
D_3T_3	103.40	31.82	50.24	92.13	495.05
D_3T_4	118.75	29.10	47.62	87.33	384.00
CD at 5%	4.46	2.11	2.32	NS	45.18

attributed to more CO_2 available for photosynthesis due to chimney effect as plastic mulches are impervious to carbon dioxide resulting in abundant CO_2 for plants which have resulted in higher plant growth and development. Similarly, Bhatt *et al*. (2011) also noticed that the use of black plastic much increased the plant spread by 22.4 % and advanced the flowering time by four to five days in summer squash under favourable climatic condition of mid-hills of Uttarakhand during summers, while under unfavourable climatic condition of *tarai* during winter use of black plastic mulch increase the spread of plant by 42.5% and use of mulch along with plastic tunnel the increase in spread by 82.0% during the present study.

Yield and yield attributes: Positive influence of planting dates, low cost protected cultivation techniques tested during the studied and their interaction was noticed for early fruit harvest, crop duration and fruit yield of summer squash. Delaying the transplanting time from 15th November to 15th January delays the earliness by four days, of which 15th December and 15th January took 49 days to first harvest in both. Similarly, use of black plastic mulch in combination with low tunnel advanced the harvesting time by 15 days compared to control (58.55). Interactive effect of these two factors reveals the significantly lesser number of days were taken by combination of these factors compared to other treatments whereas, non significant effect was recorded for total crop duration. Mulching with black polyfilm in plastic low tunnel took minimum days to first harvest when transplanted on 15th November (39.67), whereas transplanting of summer squash on 15th January under open condition took maximum (59) days (Table 2). Increase in yield was also observed with increasing the planting time form 15th November (301.89 q/ha) to 15th January (387.32 q/ha), whereas planting on 15th December and 15th January was *at par* with this respect (Table 1). Similarly, black plastic mulch in combination with low tunnel (451.67 q/ha) increased the yield by 4.24 times than open field planting (106.32 q/ha). While the use of low tunnel (352.12 q/ha) and black plastic mulch (412.05 q/ha) alone increase the yield by 3.31 and 3.87 times compared to open field control in this regard. Among twelve treatment combinations presented in table 2, the maximum crop duration and total yield (495.32 q/ha) were recorded in summer squash grown in low tunnel having black plastic mulch with 15th December transplanting and was 5.66 times higher over open field grown squash planted on 15th November under open condition. The increase in yield and duration of cropping period observed with different transplanting dated was attributed to the favorable microclimate for growth and development during the crop period. Whereas, increase in fruit yield per plant by using low cost protected structures might be on account of higher vegetative growth due to rise in soil temperature and better microclimate promoting higher photosynthesis due to more uptakes of nutrients. Hence in this situation dry matter accumulation and partitioning was better at different plants parts, which lead to higher yield. Treatments having both low tunnel and black plastic mulch were observed better than their individual's effect. These results have similarities with the findings of Pimpini *et al.* (1987) in which, mulch and tunnel increased the yield of tomato by 54 % of which 25 % increase in yield occur during first four harvest. Higher yield of pepper due to increase in soil temperature under plastic tunnel was also observed by Gerber *et al.* (1988). Abak *et al.* (1990) recorded increase in yield of pepper (21%), eggplant (21 %), melon (67%) and water melon (98%) by application of plastic mulch.

Economic feasibility: The data indicated in table 3 shows that the maximum cultivation cost of `1,29,873 $ha^{-1}$ in this study was incurred in 15th January transplanting planting. Similarly, higher cultivation cost of summer squash (` 1,85,090 ha^{-1}) was worked out in treatment having low tunnel with black plastic mulch and was 2.44 times higher compared to open cultivation *i.e.* traditional practices (`75,954). The gross and net returns in different planting dates, low cost protected techniques and combinations of both of these were worked out based on prevalent wages, rate of

Table 3. Effect of transplanting dates and low cost protected techniques on economics of summer squash (Pooled data of both the year).

Treatments	Cost of cultivation (`/ha) Transplanting dates D_1	D_2	D_3	Mean	Gross return (`/ha) Transplanting dates D_1	D_1	D_1	Mean	Net return (`/ha) Transplanting dates D_1	D_2	D_3	Mean	Benefit : Cost Ratio Transplanting dates D_1	D_2	D_3	Mean
T1: Open Condition	75,778	75,683	76,400	75,945	87,450	80,560	1,11,970	93,327	11,672	4,877	74,570	30,373	1.15	1.06	1.97	1.39
T2: Low tunnel + Black plastic	1,84,577	1,85,833	1,84,861	1,85,090	4,15,660	4,95,320	4,40,340	4,50,440	2,31,083	2,23,423	2,80,479	2,44,995	2.25	2.66	1.79	2.23
T3: Black plastic	1,10,221	1,11,222	1,12,122	1,11,188	3,05,750	3,95,350	4,95,350	3,98,817	1,95,529	2,84,128	3,83,228	2,87,628	2.77	3.55	4.41	3.58
T4 : Low tunnel	1,45,499	1,45,961	1,46,110	1,45,857	3,20,050	3,52,320	3,84,000	3,52,123	1,74,551	2,06,359	2,47,890	2,09,600	2.19	2.59	2.82	2.53
Mean	1,29,019	1,29,675	1,29,873		2,82,228	3,30,888	3,57,915		1,53,209	1,79,697	2,46,542		2.09	2.46	2.75	

critical inputs and average selling price of produce. Among the three planting dates, highest gross return (`3,57,915 ha$^{-1}$), net profit (`2,46,542 ha^{-1}) and benefit - cost ratio (2.75) were obtained in 15th January transplanting however, among the three low cost protected techniques tested in this study, black polyethylene mulch in combination with low tunnel showed maximum gross return of `4,50,440 ha$^{-1}$. While, the maximum net return (`2,87,628 ha^{-1}) and benefit: cost ratio of 3.58 was obtained in treatment having black plastic mulch alone. Among different treatment combinations, transplanting of summer squash on 15th January using black plastic mulch was observed as best in getting maximum gross (`4,95,350), net return ( `3,83,228) and benefit - cost ratio (4.41). The increased net return and higher benefit - cost ratio under different planting dated were attributed due to higher fruits yield. The higher value for gross and net return in treatment having black plastic mulch under low tunnel could be due to higher fruit yield leading to higher net and gross yield. Similar to the present study, Bhatt *et. al.* (2011) also observed higher B:C ratio 2.61 using the black plastic mulch compared to 1.79 under open field condition. Whereas, in present study open field condition of summer gave the B:C ratio of 1.39 and was increased to 3.58 under black plastic mulch and 2.53 using plastic tunnel alone. Higher benefit - cost ratio under observed in black plastic mulch compared to tunnel and tunnel having black plastic mulch (2.23) was due additional cost required in erection of low tunnel. Growing of summer squash using low cost protected techniques resulted in much higher yield and profit irrespective of planting dates compared to those grown in open field.

Conclusion

Based on the findings of present investigation, it could be concluded that under *tarai* condition of Uttarakhand summer squash transplanted on 15th January under black polyethylene mulch is most profitable in terms of getting maximum benefit cost ratio of 4.41. Hence, the same is recommended for commercial cultivation of summer squash at farmer's field under *tarai* condition of Uttarakhand.

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