Indian Journal of Agricultural Sciences **85** (12): 1529–33, December 2015/Article

Effect of transplanting dates and mulching materials on growth, yield and economics of summer squash (*Cucurbita pepo*) in Uttarakhand hills

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Recieved: 23 July 2014; Accepted: 1 September 2015

ABSTRACT

A study was undertaken to investigate the effect of different dates of transplanting and mulching materials on plant growth, yield and economics of summer squash (*Cucurbita pepo* L.) under rainfed condition in Uttarakhand hills during spring summer season of 2011 and 2012. Summer squash was mulched with black polyethylene, pine needle, FYM and dried leaves along with and without mulched (control) and transplanted at three different dates, i.e. 10 March, 25 March and 9 April in Factorial RBD replicated thrice. During the study, observations on plant height, plant spread, leaf area, days to 50 % flowering, number of harvesting, number of fruits/plant, total yield etc. were recorded. In addition, to assess the profitability of treatments cost of cultivation, net profit and benefit cost ratio were also worked out. Among three transplanting dates, 10 March was found to be best with respect to plant growth characters, total yield (61.35 tonnes/ha), net return (₹ 452897/ha) and benefit cost ratio (3.82). Similarly, out of four mulches and control, black polyethylene mulch was observed the best with respect to plant growth characters, total yield (68.50 t/ha), net return (₹ 449732/ha) and benefit cost ratio (3.58). So far interaction between transplanting dates and mulching materials used, out of 15 treatment combinations, D_1M_1 (transplanting on 10 March under black polyethylene) had recorded maximum yield of 76.03 tonnes/ha along with highest net profit of ₹ 582242/ha and benefit cost ratio of 4.27. Based on overall performance, it could be concluded that under the prevalent climatic condition of Uttarakhand hills, treatment combination D_1M_1 (transplanting on 10 March under black polyethylene) is the best and most economical treatment, hence, recommended for commercial cultivation at farmers fields, provided all other scientific management practices are followed.

Key words: Black polyethylene, Economics, Mid-hills, Mulch, Summer squash, Uttarakhand

Summer squash (*Cucurbita pepo* L.), known as vegetable marrow, field pumpkin, *vilayatikaddu* or *chappan kaddu* in different parts of the country, is a crop of mild weather characterized by quick growth, early maturity and high yield. It is a member of cucurbitaceae and is placed in the genus *Cucurbita* along with pumpkins and winter squash. It performs well in cool and moist climatic condition and requires approximately 16-27 °C temperature for its optimum growth and development. It is a compact bushy plant with reduced size tendrils. Generally, male flowers appear first in the plants, but in a few hybrids female flower could be seen before the formation of male flowers. More or less in most of the varieties, fruits become ready for first picking in about 50-60 days after sowing. Although, summer squash is a lesser known cucurbit in Uttarakhand hills, but it has a great production potential under mid hills climatic condition during spring summer. Ease in cultivation, quick growth, higher yield and off-season nature of crop lead to higher returns per unit area under small and scattered land holdings, thus attracting number of vegetable growers toward its cultivation in hills of Uttarakhand (Bhatt *et al.* 2011).

In spite of favourable climatic condition in Uttarakhand. Low temperature during initial growth period followed by temperature fluctuations in latter part of the growth, moisture stress, less and erratic precipitation, depletion in available soil moisture due to increase in temperature and high wind velocity are some of the major constraints, which restrict the commercial cultivation of summer squash in Uttarakhand hills. Therefore, adjustment in planting time and conservation of soil moisture through mulching can help to overcome these problems to a great extent.

Research findings available so far revealed that the use of mulching in vegetable cultivation is one of the most efficient management tools for conserving the soil moisture. Mulching is the process of covering the soil surface around the plants to conserve the soil moisture, to reduce the weed population, besides providing favourable condition

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for seed germination, growth and development of the plant, which ultimately increases total and early yield in summer squash, to the tune of 30% and 29%, respectively (Sari *et al.* 1994). Mulching reduces soil compaction and crusting, fertilizer leaching, evaporation etc. reduction in labour requirement and drudgery as crop raising is labour intensive due to lack of mechanization in hill agriculture (Singh and Singh 2010). Amongst the different coloured plastic film, mulching with black plastic was found most efficient in Uttarakhand hills (Bhatt *et al.* 2011).

Use of pine needles, dry leaves and FYM and inorganic mulch materials like plastic film of different colours have great potential as mulch materials in hilly areas as they conserve the soil moisture, influence and regulate soil temperature, control weeds and improve the fertility level of the soil. Thus, considering the importance of summer squash as off season vegetable and in order to achieve the maximum returns under rainfed hill farming there is a need to standardize the optimum planting time under open and mulched conditions to maximize returns.

MATERIALS AND METHODS

A study was conducted at Vegetable Research Block of College of Forestry and Hill Agriculture, GBPUA&T, Hill Campus, Ranichauri, Tehri Garhwal, Uttarakhand during 2011-2012 to evaluate the performance the summer squash transplanted at three different dates under different mulch materials. The experimental site falls in Western Himalayas region of Uttarakhand with an altitude of 2 000 m above mean sea level. It is located at 30º15'N latitude and 78º50'E longitude. The climatic condition of the area is moist temperate, with mild summers and cool winters. Generally, monsoon showers starts during second or third week of June, with a mean annual rainfall of 1 240 mm, out of which 80 to 90% is normally experienced during June to September (Table 1). Soil samples were taken from 20 cm depth and composite sample was analyzed. The soil of experimental site was clay loam in texture, slightly acidic in nature having a pH of 6.1 with available carbon of 6.14%. The available N, P and K contents were 366 kg/ha, 37.45 kg/ha and 587 kg/ha, respectively. The experiment was conducted during spring summer seasons of 2011 and 2012 with summer squash Hybrid Ducato. The experiment was laid out in Two Factorial Randomized Block Design with three replications. The first factor was the three transplanting dates, viz. 10 March (D_1), 25 March (D_2) and 09 April (D_3) and second factor was mulch materials, i.e. black polyethylene (M_1), pine needle (M_2), FYM (M_3) and dry leaves (M_{4-}) along with un-mulched control (M_0) during both the years of the study. The recommended dose of FYM @ 20 tonnes/ha and fertilizers N,P,K @ 100, 80 and 60 kg/ha were applied uniformly in each plots. The summer squash seedlings were raised in polybags under naturally ventilated polyhouse and transplanted in the plot size 2 m × 3 m at a spacing of 1.00 m × 0.75 m followed application of mulch material of 6-7 cm thickness in case of pine needles and dried leaves, while a 3-4 cm thick mulch layer was maintained for FYM. The plastic mulching is done with plastic film of 50 micron thickness. The control treatment was left without mulch, i.e. traditional or conventional practices. Observations for vegetative parameters were recorded by using standard techniques in summer squash. The economics of summer squash was calculated taking consideration of all inputs and operational cost as well as wages of labours incurred since seed sowing for nursery raising to final picking with expenditure on marketing and transportation. The gross and net returns were worked out accordingly by taking cost of cultivation and average sale price of fruits which varies from ₹ 11.00 to ₹ 7.00/kg. The data recorded for both the years were analyzed using design of experiment as suggested by Panse and Sukhatme (1989) and pooled data were presented.

Table 1 Pooled meteorological data during the experimentation period February to June 2011-2012

Month	Temperature (°C)		Rainfall (mm)	Average RH (%)	Wind speed (Km/h)	Sunshine (h)
	Max.	Min.				
February	12.5	3.0	122.9	70.5	4.6	5.9
March	18.3	6.7	13.8	58.0	4.5	7.4
April	21.2	9.2	34.3	52.5	3.8	7.5
May	24.9	13.0	83.5	60.5	3.4	9.1
June	23.1	14.6	281.7	82.0	2.0	5.9

RESULTS AND DISCUSSION

Growth and yield attributes

Two years pooled data of biometric parameters, viz. plant height, plant spread, number of leaves per plant, leaf area, root length and root fresh weight and yield attributing characters like days taken to flowering, days to first harvesting and per plant yield of summer squash were significantly influenced by different dates of transplanting and with mulch materials used (Table 2). Amongst the different dates of transplanting, D_1 recorded maximum plant height (45.65 cm), plant spread (125.02 cm), number of leaves/plant (37.41), leaf area/plant (512.50 cm^2), root length (41.50 cm), root fresh weight (30.53 g), number of harvesting (9.40) and yield/plant (4.64 kg) which were significantly higher than D_2 except for plant height, root length, number of harvesting and yield/plant. Both these transplanting dates were significantly better to D_3 in all the above mentioned characters. The earliness indicated in terms of minimum number of days taken flowering and days to 1st harvesting were observed in 9th April transplanting and was statistically better than earlier transplanting dates, while the D_2 was also significantly better in advancing earliness than earliest transplanting D_1.

As far as different mulch materials are concerned, except the number of harvesting all the other growth and yield attributes of summer squash were significantly influenced by the different mulch materials used. The significantly better results in terms of maximum plant height

Table 2 Effect of transplanting dates and mulching on growth and yield of summer squash

Treatment	Plant height (cm)	Plant spread (cm)	No of leaves/ plant	Leaf area/plant (cm^2)	Root length (cm)	Root fresh weight	Days to 50% flowering		Days to 1st harvest	No. of harvesting	Yield (kg/ plant)	Total yield (t/ha)
							Female	Male				
Dates of transplanting												
10 March (D_1)	45.65	125.02	37.41	512.50	41.50	30.53	37.43	45.43	55.00	9.40	4.64	61.35
25 March (D_2)	43.87	119.65	35.18	473.20	38.46	25.36	34.57	37.00	48.60	8.80	4.24	57.41
9 April (D_3)	41.69	112.30	33.27	452.32	34.92	17.86	31.03	34.67	40.00	7.40	3.30	43.83
CD (P= 0.05)	1.68	4.30	1.72	15.18	3.04	1.83	1.38	1.48	1.24	0.75	0.57	5.83
Mulch materials												
Black polyethylene (M_1)	50.37	136.55	43.20	527.20	43.20	28.83	30.80	34.55	40.03	9.97	5.20	68.50
Pine needles (M_2)	44.58	119.32	34.41	485.50	39.85	25.50	35.76	41.00	49.89	8.64	4.20	56.53
FYM (M_3)	43.20	111.13	33.10	457.20	36.68	24.75	35.67	40.44	49.22	8.60	3.78	49.57
Dried leaves (M_4)	43.97	117.40	33.72	472.80	38.02	24.64	34.50	39.60	50.22	8.50	4.00	54.10
Control (M_0)	36.56	110.43	32.03	455.02	33.78	19.10	35.00	39.67	49.77	8.02	3.17	42.30
CD (P= 0.05)	2.15	5.76	2.20	18.25	4.08	1.92	1.92	1.90	1.70	NS	0.72	7.26

(50.37 cm), plant spread (136.55 cm), number of leaves/plant (43.20), leaf area/plant (527.20 cm^2), root length (43.20 cm), root fresh weight (28.83 g), and yield/plant (5.20 kg) were recorded with black polyethylene mulch (M_1). Besides this it also impart earliness by advancing male and female flowering and early harvesting compared to other mulch materials and un-mulched condition.

The interactive effect of dates of transplanting and mulch materials used were observed to be non-significant for plant height, plant spread, number of leaves/plant, root length, root fresh weight and number of harvesting (Table 3). Whereas, significant interaction were noted only for leaf area/plant, days to 50% male and female flowering and yield/plant. Summer squash plant mulched with black plastic and transplanted on 10th March (D_1M_1) produced significantly more leaf area (570.11 cm^2), followed by D_2M_1 (514.11 cm^2). Whereas, days to 50% male and female and yield/plant are concerned D_1M_1 and D_2M_1 were statistically at par.

The increase in vegetative growth and yield attributes observed with early transplanting date and decreased with later transplanting, as earlier transplanting crop has more time available for vegetative growth and utilization of nutrients from soil, leading to better plant growth and development. The present findings are in close conformity with work of Singh and Singh (2010) who reported vigorous

Table 3 Interaction effect of dates of transplanting and mulch materials in summer squash

Treatment	Plant height (cm)	Plant spread	No of leaves/ plant	Leaf area/plant (cm^2)	Root length (cm)	Root fresh weight (g)	Days to 50% flowering		Days to 1st harvest	No. of harvesting	Yield plant	Total yield (t/ha)
							Female	Male				
$D_1 M_0$	37.42	117.56	33.54	490.17	34.73	22.66	39.00	47.00	56.33	9.00	3.88	51.27
M_1	50.63	138.88	46.55	570.11	47.56	33.75	34.67	39.67	46.33	10.67	5.80	76.03
M_2	47.00	127.76	35.20	506.97	44.20	31.53	37.33	46.67	56.67	9.67	4.64	62.20
M_3	45.77	116.40	35.56	475.38	37.50	30.85	37.67	46.33	58.00	10.00	4.37	57.54
M_4	47.35	123.72	36.12	503.90	40.20	30.76	35.33	46.67	57.67	9.00	4.40	59.30
$D_2 M_0$	37.38	108.93	32.36	451.29	33.90	19.96	39.33	40.00	50.33	8.67	3.30	44.29
M_1	50.40	138.32	42.70	514.11	43.86	29.91	33.00	34.33	40.67	9.33	5.50	72.85
M_2	44.15	120.15	34.69	472.71	39.02	25.50	35.33	37.33	52.00	9.50	4.38	59.03
M_3	42.80	110.61	33.35	457.45	37.29	25.35	35.67	37.67	49.00	9.33	4.14	54.45
M_4	44.37	117.96	32.61	473.20	38.50	25.44	33.67	35.67	51.00	9.33	4.19	56.62
$D_3 M_0$	34.87	104.81	30.18	423.59	32.72	14.72	35.00	33.00	42.67	7.33	2.30	31.32
M_1	50.10	132.44	40.36	497.36	38.17	22.84	30.80	30.67	33.67	7.67	4.29	56.60
M_2	42.61	110.04	33.35	470.72	36.35	19.47	35.76	37.00	41.00	7.50	3.56	48.36
M_3	41.04	107.85	30.20	438.78	35.25	18.05	35.67	38.00	40.67	7.16	2.81	36.72
M_4	40.20	109.03	32.44	441.31	35.37	17.70	34.50	37.33	42.00	8.00	3.41	46.37
CD (P= 0.05)	NS	NS	NS	31.64	NS	NS	3.74	3.19	NS	NS	1.30	13.54

growth of tomato with early planting. Out of different mulch materials, the black polyethylene mulch recorded the significantly higher values for these attributes owing to the enhancement of photosynthesis and other metabolic activities under favourable soil microclimatic condition in terms of higher soil temperature and easy availability of soil moisture led to early growth and development. The increase in plant height under black polyethylene mulch was also reported by Mahmood *et al*. (2002) and Ekinchi and Dursun (2009). Singh *et al*. (2005) reported higher spreading of plants under plastic mulch due to more CO_2 available for photosynthesis (due to chimney effect) as plastic mulches are impervious to carbon dioxide. Organic mulches also promote better growth and development by exerting favourable influence on moisture availability, reduces the fluctuation in soil temperature and providing more nutrient through decomposition of organic matters (Uniyal and Mishra 2003).

The minimum number of days taken to male and female flowering was observed under late transplanting date (9 April), the more days taken for flowering by plant in early transplanting was due to lower temperature in the initial stage of growth while temperature increased gradually during later stages, which favors early flowering. Amongst the mulches, earliest flowering under black plastic mulches was attributed to early growth and development due to higher soil temperature, better soil microclimate that enhanced early flowering (Bhatt *et al.* 2011). The more number of days taken by organic mulches for 50% male and female flowering might be attributed to cooling effect of organic mulches which delays the flowering compared to without mulched condition. Earlier studies made by Singh *et al.* (2005) and Bhatt *et al.* (2011) also support the present findings.

Crop yield

The total yield of summer squash was significantly influenced by both, the dates of transplanting, mulch materials used and their interaction. Earliest planting, i.e. D_1 produced maximum yield (61.35 tonnes/ha) and was at par with D_2 (57.41 tonnes/ha) and both were significantly better over D_3 (43.83 tonnes/ha). Amongst the different mulch materials used, black polyethylene recorded significantly higher fruit yield of 68.50 tonnes/ha, which was 61.94% higher than without mulch (control). Organic mulches were also significantly better in terms of total yield over conventional practices, but were at par to each other. Summer squash plants mulched with black plastic and transplanted on 10 March (76.03 tonnes/ha) and D_2 (72.85 tonnes/ha) were significantly better over other treatment combination, but were statistically similar to each other. Summer squash mulch with black polyethylene transplanted on 10th March recorded 143% higher fruit yield over from without mulch plots transplanted on 9 April.

The highest yield obtained with first date of transplanting (10 March) and being gradually reduced as the reduction in the yield was due to lesser vegetative

Table 4 Effect of dates of transplanting and mulching materials on economics of summer squash

Treatment	Cost of cultivation/ha				Gross return/ha				Net return/ha				B:C ratio			
	10 March (D_1)	25 March (D_2)	9 April (D_3)	Mean	10 March (D_1)	25 March (D_2)	9 April (D_3)	Mean	10 March (D_1)	25 March (D_2)	9 April (D_3)	Mean	10 March (D_1)	25 March (D_2)	9 April (D_3)	Mean
Black polyethylene (M_1)	178058	174648	166848	173185	760300	655650	452800	622917	582242	481002	285952	449732	4.27	3.75	2.71	3.58
Pine needle (M_2)	161765	160382	153982	158710	622000	531270	386880	513383	460235	370888	232890	354671	3.84	3.31	2.51	3.22
FYM (M_3)	160681	158432	149532	156215	575400	490050	293760	453070	414719	331618	144228	296855	3.59	3.09	1.96	2.90
Dried leaves (M_4)	159598	159215	153731	157515	593000	509580	370960	491180	433402	350365	217229	333665	3.71	3.2	2.41	3.10
Control (M_0)	138815	136081	129665	134854	512700	398610	250560	387290	373885	262529	120895	252436	3.7	2.93	1.93	2.87
Mean	**159783**	157751	150751		612680	517032	350992		452897	359280	200239		3.82	3.28	2.30	

growth. The higher magnitude of yield attributing characters as influenced by higher soil temperature and moisture gave higher yield under black plastic mulch as compared to control. These results are in conformity with the findings of several workers, viz. Bhatt *et al*. (2011) and Dixit and Majumdar (1995). The positive response of organic mulches was also reported by Uniyal and Mishra (2003) and Awasthi *et al*. (2006). The twin effect of early planting and black polyethylene mulch was evident when summer squash was planted on 10 March under black plastic, similar results of early planting under plastic mulching was also reported by Singh *et al*. (2005).

Economic feasibility

The data presented in Table 4 indicated that the maximum cultivation cost of ₹ 159 783.40/ha was obtained in first date of transplanting D_1 and least expenditures occurred in third date of transplanting (₹ 150 751.60/ha). Similarly, significantly higher cultivation cost of summer squash was recorded under black plastic mulch (₹ 173 185.00/ha) as compared to organic mulches and control. Organic mulches were at par with respect to cost of cultivation and require significantly more cost of cultivation compared to control.

The gross and net returns incurred from different transplanting dates, mulch materials and treatment combinations (D × M), were worked out based on prevalent wages, rate of critical inputs and average selling price of produce. Out of three dates of transplanting, the highest gross return (₹ 612 680/ha), net profit (₹ 452 897/ha) and benefit cost ratio (3.82) was obtained with first date of transplanting D_1. All the mulch materials tested in the study proved to be slightly better with respect to control in achieving higher gross return and net profit. Out of five mulch treatments including control, the significantly higher gross return of ₹ 622 917/ha along with maximum net return (₹ 449 732/ha) and B: C ratio (3.58) was obtained from black polyethylene mulch. Minimum net return of ₹ 252 436.60/ ha and cost benefit ratio of 1.93 was obtained from traditional practices. The organic mulches did not statistically differ from each other in terms of gross and net return.

Among the different treatment combinations, D_1M_1 showed the superiority to all other treatment combinations in terms of achieving higher gross and net return along with benefit cost ratio, i.e. ₹ 760 300/ha, ₹ 582 242/ha and 4.27, respectively, followed by the treatment combination of M_1D_2. Minimum net return and B:C ratio was recorded from treatment combination of M_0D_3. The first two dates were statistically at par amongst the organic mulch in this respect.

The increased net return and higher B: C ratio under different dates of transplanting and mulch materials was attributed to higher early and total yield giving higher economic return to the grower. Similar findingsin terms of gross return, net return and B:C ratio has also been reported by Asaduzzaman *et al*. (2010) in chilli and Bhatt *et al*. (2011) in summer squash and Hallidri (2001) in cucumber.

Based on the present investigation, it could be concluded that the summer squash transplanted on 10 March under black polyethylene is the most profitable treatment combination in respect to plant growth, early harvesting, yield and maximum net profit under rainfed condition of Uttarakhand hills. Mulching with organic sources available in the area indicated that 10 March and 25 March transplanting dates equally effective in getting higher yield and economic returns. Amongst organic mulches, pine needle was found to be best in respect to yield and economic benefits. Hence, recommended for commercial cultivation at farmers' fields, provided all other scientific management practices are followed.

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