



Effect of Mulch or without Mulch on Growth, Yield, Quality and Economics of Different Intercrops in Kinnow Orchard under Semi-arid Irrigated Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out with the objective to find best suited intercrop for bearing kinnow orchard at village Balsamand of district Hisar during the years 2020 and 2021. Four vegetable crops viz. watermelon, cantaloupe, chilli, tomato and control (sole kinnow) were selected as intercrops and transplanted on silver on black mulch. In mulched plots plant height/vine length, number of fruits plant⁻¹, average fruit weight, fruit weight plant⁻¹ and yield (q/ha) was recorded higher than without mulched plots. No significant difference in fruit length of watermelon, cantaloupe and tomato during first year and watermelon and tomato during succeeding year was

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recorded in mulched plots. Mulch influenced the fruit width of watermelon during both the years. The BCR ratio was recorded higher in without mulched plots in all the crops except watermelon recorded higher BCR in mulched plots during 2021. The highest benefit cost ratio in all the crops was recorded higher in without mulched plots of watermelon, cantaloupe, chilli and tomato crop (1:5.84, 1:5.17, 1:2.99 and 1:2.71) and (1:5.01, 1:5.06, 1:2.64 and 1:2.60) during 2020 and 2021, except in watermelon crop where highest benefit cost ratio (1:5.17) was observed in watermelon crop in mulched plots during 2021.

Keywords: Growth; yield; quality and economics of different intercrops; orchard irrigated conditions.

1. INTRODUCTION

Among subtropical fruit crops citrus occupies a prominent place and is ranked third in area and production after banana and mango. It is one of the most relevant fruit crops grown across the globe and has a tremendous social, cultural and economic influence on our society [1].

As per the 3rd advance estimates of Anonymous, [2] citrus fruits are grown in 1058 thousand hectare area producing 14032 thousand metric ton fruits while mandarin is grown in area of 479 thousand hectare and producing about 6397 thousand metric ton. Mandarin occupies nearly 45.27 % of the total area under citrus cultivation in India with ever increasing area year after year. Kinnow is a high yielding mandarin hybrid cultivated extensively in the wider region of Punjab in Pakistan and India. Kinnow fruits are globular in shape and orange in color, its uniqueness is assortment in between mandarin and sweet orange fruits with neither tight nor loose skin [3]. It is a hybrid of two citrus cultivars *Citrus nobilis* × *Citrus deliciosa*.

In Haryana (2020–21), citrus fruits were grown on 23316 hectare area with the production of 517828 MT. In Haryana, the major districts growing citrus are Sirsa, Fatehabad, Bhiwani, Hisar, Narnaul and having 11392, 2753, 2342, 2211, 1390 hectare area with the production of 268170, 78995, 57516, 28105, and 38550 MT respectively [4]

The vegetable crops are best suited as intercrops because they are short durational species in comparison to other species and can be easily grown in between the interrow space of fruit orchards [5]. The most common vegetable crops grown as intercrop in fruit orchards are Okra, French bean, Brinjal, Cauliflower, Pea, Arvi, Elephant foot yam, Bottle gourd, Pumpkin, Watermelon, Muskmelon, Turmeric, Bunda, and Radish etc [6,7,8,9]. Intercropping systems

commonly followed by farmers in different parts of the country e.g. Coconut based intercropping system, Mango based intercropping system, papaya based intercropping system, Vegetable crops based intercropping system, Strawberry-vegetable based intercropping system, Coconut based mixed cropping system, Citrus-watermelon based intercropping system, Guava-elephant foot yam based cropping system, etc [10,11].

Mulching is an effective practice used in vegetable crops having significant effect on growth, yield, and soil moisture status and improves the nutrient status of soil [12,13,14]. It has positive effect on the cultivated crops in a number of ways such as regulate soil temperature, maintains soil moisture, controls and checks weed growth, reduces loss of water and leaching of agrochemical, protects from soil dirt and diseases [15].

2. MATERIALS AND METHODS

The experiment was conducted at orchard situated in village Balsamand (Hisar). The orchard is situated at 215.2 m above mean sea level with coordinates of 29°07' N latitude and 75°51' E longitudes. Hisar has a typical semi-arid climate with hot and dry summers and extremely cold winters. The mean monthly maximum and minimum temperature show a wide range of variations both during summer and winter months. A maximum temperature of around 45°C during summer months of May to June and temperature as low as freezing point accompanied by occasional frost in winter months of December and January. The total rainfall as well as its distribution in the region is subjected to large variations. About 80 per cent of the annual rainfall (about 450 mm) is received during July to September. A few showers also occur from December to February due to the western disturbances. The rainfall is highly erratic with 20-30 per cent annual and 30-50 per cent seasonal variations.

Citrus plants in the orchard were kept under uniform orchard management practices during the study, where all the cultural practices were carried out as per package of practices for fruit crops, CCS HAU, Hisar. Locally available hybrids of water melon, cantaloupe, chilli and tomato (selection-7) were taken. The seedlings were raised in portraits in polyhouse during January-February to avoid delay in transplanting and poor germination under open field conditions.

The observations for traits like, Plant height /Vine length at 30 days, 60 days and at final harvest (cm), Number of fruits/plant, Average fruit weight (gm.), Weight of fruits plant⁻¹ (kg), and Yield (q/ha), Fruit length (cm), Fruit width (cm), and TSS (%) and Economics (BCR) of with or without mulched intercrops water melon, cantaloupe, chilli and tomato in kinnow orchard were recorded on whole plot basis.

Data recorded was compiled and subjected to statistical analysis (Panse and Sukhatme, 1987) as per the design of the experiment (Factorial RBD).

3. RESULTS AND DISCUSSION

3.1 Observations of different Intercrops With and Without Mulch

3.1.1 Plant height /Vine length at 30 days, 60 days and at final harvest (cm)

The plant height/vine length 30 DAT for watermelon (109 cm) and cantaloupe (108.33 cm) varied significantly in mulched plots as compared with without mulched plots (97 & 98 cm). While no significant difference was

observed in mulched plots of chilli and tomato crops, however numerically more plant height was recorded in mulched plots as compared to without mulched plots during the years 2020 & 2021. At initial stage after transplanting of intercrops tomato and chilli has taken more time in establishing i.e. transplantation shock as compared to watermelon and cantaloupe.

During mid-season of the crops no significant difference in vine length of watermelon and cantaloupe was recorded in mulched and without mulched plots during 2020, however during 2021 watermelon and cantaloupe had a significant influence in vine length, this may be probably because of dry spell during hot summer months of the year 2020 and occasional showers during 2021 favored more spread in vine length. In chilli and tomato crops significant difference in plant height was observed during both the years in mulched plots. After completing of establishment phase, in mulched plots loss of soil moisture and nutrients was less, which favored speedy growth of plants.

At final harvest vine length of watermelon and cantaloupe differed significantly and recorded higher in mulched plots, but no significant difference was observed in chilli and tomato. This might be because of spreading nature of watermelon and cantaloupe plants, while in chilli and tomato plants more number of side branches emerges after a certain period growth as shown in Table 2. The results are in confirmation with the findings of Singh et al. [16], Aruna et al. [17] in tomato, Parmar et al. [18], Dean ban et al. [19], Ansary and Roy. [20] in watermelon, Al-Majali and Kasrawi. [21] in muskmelon, and Prajapati et al. [22] in chilli.

Table 1. Treatments detail

Factor 1: Intercrops (Five)	Crop	: Mandarin
T ₁ : Cucurbitaceous crop- Watermelon	Variety	: Kinnow
T ₂ : Cucurbitaceous crop- Cantaloupe	Age of plant	: Eight Years
T ₃ : Solanaceous crop- Chilli	Spacing of plant	: 6 x 6 m
T ₄ : Solanaceous crop-Tomato	Number of replications	: Three
T ₅ : Control- No intercrop	Number of factors	: Two
Factor 2: Effect of Mulch (Two)	Factor 1	: Five
M ₁ : Intercrops with mulch	Factor 2	: Two
M ₂ : Intercrops without mulch	Treatment Combinations	: Ten
	Experimental design	: Factorial RBD

3.1.2 Number of fruits/plant, Average fruit weight (gm.), Weight of fruits plant⁻¹ (kg), and Yield (q/ha)

Mulch was found to have significantly better effect on number of fruits plant⁻¹, average fruit weight, weight of fruits plant⁻¹ and yield (q/ha) was recorded higher in mulched plots of watermelon, cantaloupe, chilli and tomato than without mulched plots, during both the years under study i.e. 2020 & 2021 (as shown in Tables 3, 4, 5, 6). This might be because of mulching consistently increased higher fruit set than without mulch. In mulched plots the favorable soil temperature, moisture conditions, nutrient status, less weed density and weed crop competition, and hence increases healthy plant growth and development. The findings are in accordance with Belel. [23] in sweet pepper, Reddy et al. [24] in red chilli, Kumawat et al. [25] in chilli, Kumar et al. [26] in chilli, tomato, brinjal and bitter guard, Ansary and Roy. [20], and Parmar. [18] in watermelon and Aruna et al. [17] in tomato.

3.1.3 Fruit length (cm), Fruit width (cm), and TSS (%)

The results indicate that mulch had significant effect on fruit length, width and TSS (%) than without mulched plots (as shown in Tables 7, 8, 9). The fruit length in chilli was significantly influenced by mulching, however so significant effect was recorded in watermelon, cantaloupe and tomato during 2020. This may be probably because of varietal characters, and shading effect of kinnow plants. In succeeding season fruit length of cantaloupe and chilli was significantly effected by mulch and no significant effect was recorded in watermelon and chilli. The fruit width of watermelon fruits had been significantly influenced by mulch as compared to without mulch; however cantaloupe, chilli and tomato were not influenced. Numerically the fruit length and width was recorded higher in watermelon, cantaloupe, chilli and tomato but statistically recorded non-significant in mulched and without mulched plots. This may be due to availability of soil moisture and nutrients in mulched plots and shading effect of kinnow plants that resulted in higher

auxins activity under shade. The TSS (%) was positively influenced by mulch in watermelon and cantaloupe, while no significant influence was recorded in chilli and tomato during both the years 2020 & 2021. In mulched plots weed intensity and competition was very less, leaching down of nutrients and evapotranspiration are checked, these conditions accelerates the plant growth and development with good quality of fruits as compared to without mulched plots. The results are in confirmation of Parmar et al. [18], Johnson et al. [27] and Ansary and Roy. [20] in watermelon, Sharma and Agarwal [28], Aruna et al. [17] in tomato.

3.1.4 Economics (BCR) of with or without mulched intercrops water melon, cantaloupe, chilli and tomato in kinnow orchard

Higher money value and less cost of cultivation are desirable traits for getting higher returns in horticultural crops. The observations recorded on BCR in (watermelon, cantaloupe, chilli and tomato) with or without mulched plots revealed that BCR was recorded higher in without mulched plots (1:5.84, 1:5.17, 1:2.99 and 1:2.71) and lower (1:5.07, 1:4.09, 1:2.72 and 1:2.20) in without mulched crops during 2020 respectively.

However during 2021 higher BCR was recorded in watermelon crop in mulched plots (1:5.17) as compared to without mulched plots, while cantaloupe, chilli and tomato recorded higher BCR (1:5.06, 1:2.64 and 1:2.60) in without mulched plots as compared to mulched plots (1:4.79, 1:2.42 and 1:2.55) during 2021 respectively (Fig. 1). The yield of all the crops was significantly higher in mulched plots during both the years 2020 & 2021. The probable reason may be higher cost of plastic mulch (silver on black) and it's laying, increased the cost of cultivation. However during 2021 the yield of watermelon was recorded much higher in mulched plots and the BCR was recorded higher as compared to without mulched plots. In contrast to our results Kumar et al. [16] recorded higher BCR in mulched intercrops and similar findings were reported by Prajapati et al. [12] and Singh et al. [6].

Table 2. Plant height/vine length (cm) of with or without mulch intercrops in kinnow orchard at 30 DAT, Mid-season and at Final harvest

Crop	30 days after transplanting 2020					Crop	30 days after transplanting 2020				
	Mulch	Without mulch	t-value	P-value	Test of significance		Mulch	Without mulch	t-value	P-value	Test of significance
Watermelon	109.00	97.00	2.48	0.05	S	Watermelon	112.00	98.34	13.37	0.01	S
Cantaloupe	108.33	98.00	6.20	0.01	S	Cantaloupe	110.00	99.11	6.17	0.03	S
Chilli	30.00	25.67	1.46	0.21	NS	Chilli	32.00	27.00	13.96	0.16	NS
Tomato	34.67	29.00	2.23	0.08	NS	Tomato	36.00	30.00	6.32	0.08	NS
Crop	Mid- season 2020					Crop	Mid-season 2021				
Watermelon	256.67	245.67	1.87	0.13	NS	Watermelon	262.00	240.00	3.14	0.03	S
Cantaloupe	281.67	267.67	0.77	0.48	NS	Cantaloupe	283.00	263.44	9.54	0.05	S
Chilli	59.67	49.00	4.20	0.01	S	Chilli	60.47	51.00	11.63	0.01	S
Tomato	62.67	55.33	1.78	0.05	S	Tomato	65.00	59.05	6.58	0.01	S
Crop	At final harvest 2020					Crop	At final harvest 2021				
Watermelon	352.67	321.33	6.04	0.01	S	Watermelon	362.00	328.67	5.29	0.01	S
Cantaloupe	335.00	300.67	2.0	0.01	S	Cantaloupe	345.87	327.00	1.22	0.04	S
Chilli	80.67	77.33	2.24	0.11	NS	Chilli	86.67	82.00	2.64	0.21	NS
Tomato	75.67	72.67	0.95	0.39	NS	Tomato	80.33	76.00	2.89	0.09	NS

*0.01 - 0.05 Significant, >0.05 Non-significant

Table 3. Number of fruits plant⁻¹ in with or without mulch intercrops in kinnow orchard

Crop	Number of fruits plant ⁻¹ 2020					Crop	Number of fruits plant ⁻¹ 2021				
	Mulch	Without mulch	t-value	P-value	Test of significance		Mulch	Without mulch	t-value	P-value	Test of significance
Watermelon	3.07	2.57	3.13	0.03	S	Watermelon	3.00	2.37	0.96	0.03	S
Cantaloupe	4.83	4.20	3.12	0.04	S	Cantaloupe	4.90	4.30	2.78	0.04	S
Chilli	248.67	238.33	2.19	0.05	S	Chilli	241.67	231.00	0.45	0.04	S
Tomato	38.67	31.53	3.38	0.02	S	Tomato	39.33	34.67	1.22	0.02	S

*0.01 - 0.05 Significant, >0.05 Non-significant

Table 4. Average fruit weight (g) in with or without mulch intercrops in kinnow orchard

Crop	Average fruit weight (g) 2020					Crop	Average fruit weight (g) 2021				
	Mulch	Without mulch	t-value	P-value	Test of significance		Mulch	Without mulch	t-value	P-value	Test of significance
Watermelon	3466.67	3176.67	0.78	0.04	S	Watermelon	3646.67	3492.00	3.28	0.03	S
Cantaloupe	971.33	946.67	0.37	0.05	S	Cantaloupe	968.14	908.33	3.54	0.02	S
Chilli	13.26	11.58	3.34	0.02	S	Chilli	12.63	11.29	3.79	0.01	S
Tomato	72.33	67.00	1.37	0.24	NS	Tomato	75.00	66.33	5.54	0.01	S

*0.01 - 0.05 Significant, >0.05 Non-significant

Table 5. Fruit weight plant⁻¹ (kg) in with or without mulch intercrops in kinnow orchard

Crop	Fruit weight plant ⁻¹ (kg) 2020					Crop	Fruit weight plant ⁻¹ (kg) 2021				
	Mulch	Without mulch	t-value	P-value	Test of significance		Mulch	Without mulch	t-value	P-value	Test of significance
Watermelon	10.63	8.15	4.50	0.01	S	Watermelon	10.917	8.310	1.09	0.03	S
Cantaloupe	4.68	3.96	3.55	0.02	S	Cantaloupe	4.743	3.901	5.55	0.01	S
Chilli	3.30	2.76	8.89	0.01	S	Chilli	3.051	2.612	1.47	0.04	S
Tomato	2.80	2.11	4.55	0.01	S	Tomato	2.951	2.294	2.44	0.05	S

*0.01 - 0.05 Significant, >0.05 Non-significant

Table 6. Yield (q/ha) in with or without mulch intercrops in kinnow orchard

Crop	Yield (q/ha) 2020					Crop	Yield (q/ha) 2021				
	Mulch	Without mulch	t-value	P-value	Test of significance		Mulch	Without mulch	t-value	P-value	Test of significance
Watermelon	294.73	265.39	0.51	0.05	S	Watermelon	303.17	230.78	1.09	0.03	S
Cantaloupe	130.16	128.81	0.12	0.91	NS	Cantaloupe	131.72	108.34	5.55	0.01	S
Chilli	91.63	77.80	2.71	0.05	S	Chilli	84.73	72.54	1.47	0.03	S
Tomato	77.53	72.67	1.33	0.05	S	Tomato	81.96	63.72	2.44	0.05	S

*0.01 - 0.05 Significant, >0.05 Non-significant

Table 7. Fruit length (cm) in with or without mulch intercrops in kinnow orchard

Crop	Average fruit length (cm) 2020					Crop	Average fruit length (cm) 2021				
	Mulch	Without mulch	t-value	P-value	Test of significance		Mulch	Without mulch	t-value	P-value	Test of significance
Watermelon	26.92	25.15	2.52	0.06	NS	Watermelon	27.09	25.55	1.94	0.12	NS
Cantaloupe	16.24	15.04	2.01	0.11	NS	Cantaloupe	16.31	15.16	3.33	0.02	S
Chilli	7.55	6.79	4.15	0.01	S	Chilli	7.23	6.71	2.52	0.05	S
Tomato	6.41	6.28	0.30	0.77	NS	Tomato	6.48	6.34	0.36	0.73	NS

*0.01 - 0.05 Significant, >0.05 Non-significant

Table 8. Fruit width (cm) in with or without mulch intercrops in kinnow orchard

Crop	Fruit width (cm) 2020					Crop	Fruit width (cm) 2021				
	Mulch	Without mulch	t-value	P-value	Test of significance		Mulch	Without mulch	t-value	P-value	Test of significance
Watermelon	15.90	14.18	5.34	0.01	S	Watermelon	15.93	14.43	8.59	0.01	S
Cantaloupe	12.30	12.01	0.67	0.54	NS	Cantaloupe	12.47	12.11	1.60	0.18	NS
Chilli	2.02	1.87	1.27	0.27	NS	Chilli	1.97	1.76	3.20	0.23	NS
Tomato	6.89	6.44	1.56	0.19	NS	Tomato	7.08	6.66	2.65	0.15	NS

*0.01 - 0.05 Significant, >0.05 Non-significant

Table 9. TSS (%) in with or without mulch intercrops in kinnow orchard

Crop	TSS (%) 2020					Crop	TSS (%) 2021				
	Mulch	Without mulch	t-value	P-value	Test of significance		Mulch	Without mulch	t-value	P-value	Test of significance
Watermelon	12.38	11.88	2.11	0.04	S	Watermelon	12.93	11.97	6.51	0.01	S
Cantaloupe	13.73	12.75	1.88	0.03	S	Cantaloupe	14.04	12.94	6.47	0.01	S
Chilli	8.45	8.0	2.27	0.08	NS	Chilli	8.50	8.09	0.82	0.45	NS
Tomato	6.96	6.50	1.81	0.14	NS	Tomato	7.17	6.79	1.37	0.24	NS

*0.01 - 0.05 Significant, >0.05 Non-significant

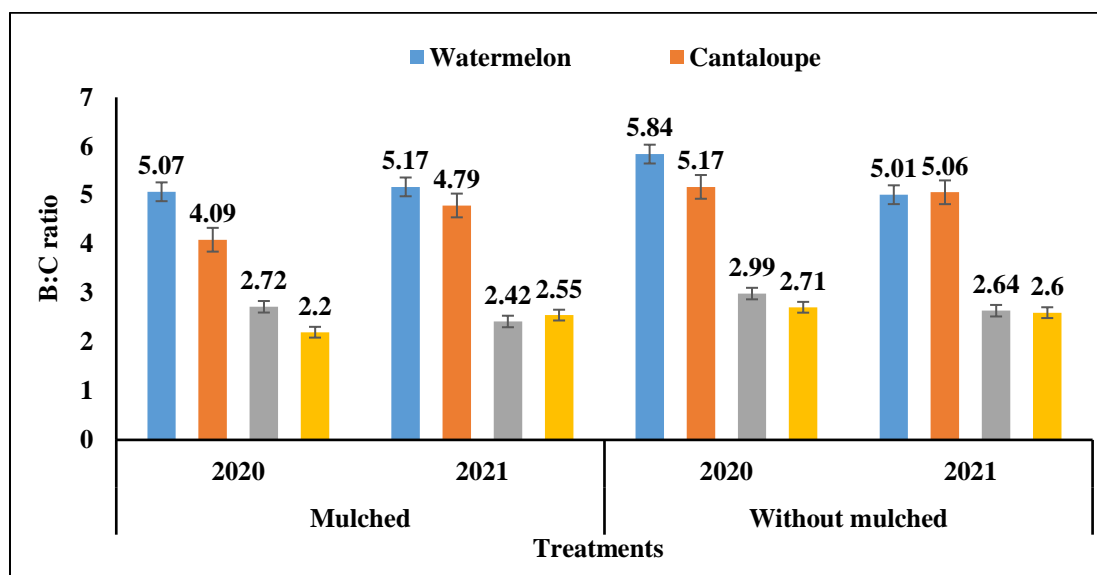


Fig. 1. Economics of with or without mulch intercrops (BCR)

4. CONCLUSION

It is concluded that mulching is an effective practice used in vegetable crops having significant effect on growth, yield, and soil moisture status and improves the nutrient status of soil. It has positive effect on the cultivated crops in a number of ways such as regulate soil temperature, maintains soil moisture, controls and checks weed growth, reduces loss of water and leaching of agrochemical, protects from soil dirt and diseases

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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