



Effect of Mulched and without Mulched Intercrops on Growth Yield and Fruit Quality of Kinnow Mandarin Plantation under Semi-Arid Irrigated Conditions

Dinesh Kumar ^{a*}, Surender Singh ^a, Indu Arora ^b, Jeet Ram Sharma ^a and Rao Pankaj ^c

^a *Department of Horticulture, Maharana Pratap Horticultural University, Karnal, 132001, CCS Haryana Agricultural University, Hisar, Haryana, India.*

^b *Department of Vegetable Science, Maharana Pratap Horticultural University, Karnal, 132001, CCS Haryana Agricultural University, Hisar, Haryana, India.*

^c *Department of Genetics and Plant Breedin, Maharana Pratap Horticultural University, Karnal, 132001, CCS Haryana Agricultural University, Hisar, Haryana, India.*

Authors' contributions

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

Article Information

DOI: 10.9734/IJECC/2022/v12i1131118

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/85383>

Original Research Article

Received 17 January 2022
Accepted 24 March 2022
Published 11 August 2022

ABSTRACT

The aim of the present was to analyze the effect of different intercrops with and without mulch on growth, yield and quality of kinnow mandarin orchard. The data of kinnow plant such as height, stem girth, canopy spread, and canopy volume were collected in the month of February 2020 before transplanting the intercrops. The intercrops under mulch and without mulch treatments have significant effect on growth of kinnow plant, the percent increase in plant height (3.22%) in kinnow + watermelon, stem girth (4.20%) in kinnow + tomato, and canopy spread EW direction (3.89%) in kinnow + cantaloupe, were found to have positive effect in mulch intercrops treatments and percent increase in canopy spread NS direction (3.76%) and canopy volume (10.84%) in kinnow + watermelon, was found in without mulch intercrops treatments. The number of fruits per tree, average fruit weight and yield were significantly affected by mulch and without mulch treatments,

with maximum number of fruits (920), fruit weight (161.11 g), and yield (361.34 q/ha) were recorded in kinnow + watermelon. TSS (11.56%), acidity (0.91%), ascorbic acid (30.15 mg/100ml juice) were recorded in without mulch intercrops treatments, and juice (42.96%), peel (27.84%) were recorded in mulch intercrops treatments.

Keywords: Kinnow mandarin; mulch; without mulch; intercrops; treatments.

1. INTRODUCTION

Citrus fruits occupy a prominent place among the fruits grown in subtropical semi-arid irrigated conditions of Indian sub-continent. Citrus fruits are the third major commercially cultivated fruit crop after mango and banana. Mandarin orange (*Citrus reticulata*) is most common among citrus fruits grows successfully in all frost-free tropical and sub-tropical regions up to 1,500 meters above mean sea level with annual rainfall of 100-120 cm and temperature ranging from 10°C to 35°C is suitable for cultivation of this crop. As per the 3rd advance estimates of NHB data (2020-21) 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. Among citrus fruits kinnow mandarin occupies a prominent place and area under its cultivation is increasing year after year in semi-arid irrigated tracts of Punjab, Haryana and Rajasthan.

Intercropping is the integrated cropping system aimed to optimize land use with maximum returns per unit of land and time, having positive effect on soil fertility and conservation, recycling of waste and insurance against less yield or failure of main crop in addition of providing employment round the year with considerable reduction in cost of cultivation [1]. Intercropping can be an alternative profitable practice in low input and high output fruit orchards of small scale farming systems, with high efficient use of land and improved technologies. The fruit orchards intercropped with legume based vegetable crops maintained higher level of nutrients in the leaves than the fruit crops without intercrops also exhibited better performance of main crop by increasing plant height, stem girth, plant canopy area, fruit weight and yield [2]. Vegetable crops are small durational crops having a small life span of single season, producing more biomass per unit area and are herbaceous in nature. Vegetable crops grown as intercrops adds organic matter, improves soil fertility of orchard

soil and makes the intercropping system ecologically sustainable and economically viable to the farmers [3].

Selection of suitable vegetable crops as intercrops with fruit orchards will make the system more economically viable to the farmers generating extra income and enhancing productivity per unit area and time. Growing of suitable vegetables with fruit crops looks remunerative but a very less information is available regarding production, economics and suitable intercrop for kinnow orchard. There is hardly any systemic research work is done on growing of suitable vegetable crop as intercrop in grown up kinnow orchard under Haryana conditions. Hence considering the above facts the present experiment was concluded to access the effect of mulch and without mulch intercrops on growth, yield and quality of kinnow fruits in semi-arid irrigated conditions of Haryana.

2. MATERIALS AND METHODS

The present investigation was carried out at progressive farmers' fields in village Balsamand of Hisar, situated at 215.2 m above mean sea level with coordinates of 29°07' N latitude and 75°51' E longitudes from February 2020 to July 2020. The region lies in the semi-arid irrigated tracts of Haryana and adjoining to Rajasthan. The region 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.

Treatment Details: T₁: Kinnow + Watermelon, T₂: Kinnow + Cantaloupe, T₃: Kinnow + Chilli, T₄: Kinnow + Tomato, T₅: Control- Sole Kinnow, M₁: Intercrops with mulch, M₂: Intercrops without mulch, Crop: Mandarin, Variety: Kinnow, Age of plant: Eight Years, Spacing of plant: 6 x 6 m. The recommended package of practice by CCS HAU, Hisar was followed during the experiment for kinnow and vegetable intercrops.

Plant height (m), Stem girth (cm), and Plant spread (m):- was measured in the first week of February before transplanting of intercrops and at final harvest of fruits with the help of meter scale.

Canopy Volume (m³): Canopy volume was calculated by the formula $V = \pi r^2 h$. Where, $\pi = 22/7$, r is the radius (spread N-S+E-W)/2, and h is the height of the tree and expressed in m³.

Number of Fruits Per Tree: The number of fruits on three plants per replication was counted by counting individual fruit per tree and the number was averaged to obtain final fruit number and expressed in numbers.

Average Fruit Weight (g): Five randomly selected fully mature fruits from chest height, one foot inside the tree canopy from all the directions were harvested and average fruit weight was calculated by dividing total fruit weight by total number of fruits from each replication with the help of top pan balance. The final fruit weight is average of three replications and expressed in grams.

Average fruit weight (g) = (Total weight of all the replications) / Number of replications

Yield (q/ha) = Yield per tree X Number of trees per hectare. Fruit yield was expressed in quintals per hectare.

Juice (%):- (Juice weight X 100) / Fruit weight

Peel (%):- (Peel weight X 100) / Fruit weight

Acidity (%) The acidity was determined by the method of A.O.A.C. [4].

Acidity = (Total value x Normality of NaOH x Eqv. weight of citric acid x 100) / Juice volume used

Ascorbic acid (mg/100 ml juice) Ascorbic acid was estimated as per the method given by A.O.A.C [4].

Ascorbic acid (mg/100 ml of fruit juice) = (Titrated value x total volume) / Standard reading x ml of juice taken

2.1 Statistical Analysis

Data recorded was compiled and subjected to statistical analysis [5] as per the design of the experiment, (Factorial RBD) and tested for variances at 5% level of significance.

3. RESULTS AND DISCUSSION

The vegetable crops grown as intercrops on both mulch and without mulch treatments found to have positive effect on the plant height, stem girth, E-W, N-S spread and canopy volume over sole kinnow crop (Table 1). The annual percent increase in plant height was 3.22 and 3.30% in kinnow + watermelon, both under mulch and without mulch conditions and 3.31% in kinnow + cantaloupe, under without mulch as compared to 3.09% in sole kinnow. In kinnow + tomato mulch 3.10% the plant height was at par with 3.09% sole kinnow, while in other treatments the percent increase in plant height was less 2.41% in kinnow + cantaloupe mulch, 2.99% and 1.92% in kinnow + chilli and 1.36% in kinnow + tomato without mulch.

Similarly the percent increase in stem girth was recorded 3.63 and 3.95%, 3.96 and 5.17%, 4.20% and 2.17% in kinnow + watermelon, kinnow + cantaloupe, mulch and without mulch, kinnow + chilli mulch respectively showed positive growth as compared to 1.47% in sole kinnow. The vegetable intercrops on mulch and without mulch treatments have positive effect on percent increase in canopy volume, the annual increase in canopy volume was 10.58 and 10.84% in kinnow + watermelon under both mulch and without mulch treatments, 9.07 and 8.44% in kinnow + chilli, 10.05 and 8.29% in kinnow + tomato in kinnow + tomato as compared to 9.53 and 9.03% in sole kinnow, under mulch and without mulch treatments. This might be due to fact that intercropping of vegetables under mulch and without mulch treatment helped in proper utilization of space, natural resources and improves the input use efficiency in the intercropping system. Under mulch the loss of nutrients, moisture, and weed growth is less and quick biodegradation of

biomass, releasing organic acids and growth hormones as compared to sole kinnow where the interspace is left uncultivated, weed growth and moisture loss are more, no additional input of nutrients, supplemental irrigation. In vegetable intercrops the additional input of fertilizer source also helped in better growth and development of kinnow mandarin plants. The positive effect of intercropping of vegetables on fruit crops have been reported by other workers in kinnow [6], citrus [7,8], Nagpur mandarin [9], mango [10], guava [10] sweet orange [11] etc.

The yield of kinnow mandarin was significantly affected by the mulch and without mulch intercrops and was recorded significantly higher in both the intercrops treatments over sole kinnow (Table 2). The maximum number of fruits per tree 920 in kinnow + watermelon, and minimum 829 in kinnow sole crop, in mulch treatment, while in without mulch intercrops maximum number of fruits per tree was recorded 840 in kinnow + cantaloupe and minimum 805 in kinnow sole crop. The higher 885 number of fruits was recorded under mulch treatment and lower 821 in without mulch treatments.

The maximum average fruit weight 161.11 g in kinnow + watermelon, 153.33 g in kinnow + cantaloupe, 150 g in chilli + kinnow, 147.56 g in kinnow + tomato, while in without mulched intercrops 155.11 g in kinnow + watermelon, 150.22 g in kinnow + cantaloupe, 145.45 g in chilli + kinnow, 139.44 g in kinnow + tomato, was higher than 134 g in sole kinnow. The fruit yield in all the mulch intercrops was recorded maximum in 410.58 (q/ha) in kinnow + watermelon, followed 387.78 (q/ha) in kinnow + cantaloupe, 369.17 (q/ha) in chilli + kinnow, 357.57 (q/ha) in kinnow + tomato, while in without mulch intercrops treatment maximum

yield 352.58 (q/ha) in kinnow + watermelon, followed by 349.53 (q/ha) in kinnow + cantaloupe, 334.42 (q/ha) in chilli + kinnow, 313.53 (q/ha) in kinnow + tomato, and minimum 298.69 (q/ha) in sole kinnow.

The fruit number per tree and fruit weight was higher in mulched treatments as compared to without mulch and sole kinnow plantation. The higher yield in mulched intercrops was obtained due to mulch which retains moisture for longer time as compared to sole kinnow and avoids loss of nutrients, enhances biodegradation of organic matter, and increases availability of nutrients to plants, suppresses weed growth reducing competition for water, nutrients, space and natural resources. The big size of leaves in watermelon and cantaloupe and spreading habit of vine covers the interspace completely and changes the microclimate of the orchard. The moisture loss through evapotranspiration interrupts convection heat, and changes the micro climate of orchard, which reduces the fruit drop and ultimately increasing the yield of kinnow plants. The supplemental irrigation with additional dose of fertilizers also helps in increasing the yield of the orchard. The positive effect of intercrops on yield of fruit trees was studied by different workers, ber crop [12], kinnow orchard intercropped with ginger, maize, finger millet, beans and vegetables produced maximum number of fruits and 10% less fruit drop [13], citrus orchard intercropped with Egyptian clover and fenugreek reduced fruit drop and enhanced fruit set yield and vegetative growth [14-18], in mango fruit weight and yield increased in intercropping system with Mango + guava + cowpea [2] in kinnow orchard intercropped with vegetable crops increased yield [6], highest yield 20.0t/ha (72.3 kg/tree) was recorded in Nagpur mandarin + soybean followed by gram [9] etc.

Table 1. Growth of kinnow mandarin affected by mulched and without mulched intercrops

Treatments	% increase in plant height (m)		% increase in stem girth (cm)		% increase in EW*spread (m)		% increase in NS**spread (m)		% increase in canopy volume (m ³)	
	Mulch	W/o mulch	Mulch	W/o mulch	Mulch	W/o mulch	Mulch	W/o mulch	Mulch	W/o mulch
T ₁	3.22	3.30	3.63	3.95	3.88	3.31	3.11	3.76	10.58	10.84
T ₂	2.41	3.31	3.96	5.17	3.89	2.66	3.41	3.38	9.84	9.68
T ₃	2.99	1.92	3.76	1.45	2.08	2.40	3.69	3.72	9.07	8.44
T ₄	3.10	1.36	4.20	2.17	3.85	3.24	2.78	3.11	10.05	8.29
T ₅	2.50	3.09	3.28	1.47	3.82	2.35	3.12	3.40	9.53	9.03
Mean	2.73	2.75	3.76	2.84	3.26	2.67	3.10	3.73	9.82	9.26

*EW- East-West, **NS- North-South

Table 2. Yield of kinnow mandarin affected by mulched and without mulched intercrops

Treatments	Fruits/tree (no)		Average fruit weight (g)		Yield q/ha	
	Mulch	W/o mulch	Mulch	W/o mulch	Mulch	W/o mulch
T ₁	920	821	161.11	155.11	410.58	352.58
T ₂	913	840	153.33	150.22	387.78	349.53
T ₃	888	830	150.00	145.45	369.17	334.42
T ₄	875	811	147.56	139.44	357.57	313.53
T ₅	829	805	141.77	134.00	307.65	298.69
Mean	885	821	150.75	144.84	366.55	329.75
CD	16	23	2.64	4.18	6.96	11.00

The (Total soluble solids) TSS was found to have negative effect 11.03 in kinnow + watermelon, 11.07 in kinnow + cantaloupe, 11.33 in chilli + kinnow, 11.30 in kinnow + tomato, as compared to without mulch intercrops and sole kinnow, 11.40 in kinnow + watermelon, 11.50 in kinnow + cantaloupe, 11.57 in chilli + kinnow, 11.57 in kinnow + tomato, was lower than 11.77 in sole kinnow, in both the mulch and without mulch treatments (Table 3). The probable reason may be more supplemental irrigation, with additional dose of fertilizers and less evapotranspiration in mulch as compared to without mulch and sole kinnow.

While the juice % was recorded higher in 47.54% in kinnow + watermelon, 46.98% in kinnow + cantaloupe, 43.27% in chilli + kinnow, 41.98 % in kinnow + tomato, and in without mulched intercrops 41.46% in kinnow + watermelon, 39.80% in kinnow + cantaloupe, 38% in chilli + kinnow, 37.86% in kinnow + tomato, was higher than 35.01% in sole kinnow. The juice % was higher in mulch as compared to without mulch and sole kinnow because of more number of supplemental irrigation, less evapotranspiration and competition with weeds.

The peel % was also recorded higher in mulch than without mulch and sole kinnow and was recorded 28.32% in kinnow + watermelon,

29.01% in kinnow + cantaloupe, 27.70% in chilli + kinnow, 27.12% in kinnow + tomato, while in without mulched intercrops 25.59% in kinnow + watermelon, 25.78% in kinnow + cantaloupe, 25.76% in chilli + kinnow, 24.94% in kinnow + tomato, than 24.94% in sole kinnow. The probable reason may be more number of irrigations and mulch which helps in keeping the soil friable and avoid loss of nutrients which upkeeps the growth of plant resulting in big size of fruits.

The acidity was recorded lower in mulch treatments, which is an indicator of more sweetness in the fruits 0.76 in kinnow + watermelon, 0.81 in kinnow + cantaloupe, 0.82 in chilli + kinnow, 0.84 in kinnow + tomato, and in without mulched intercrops 0.86 in kinnow + watermelon, 0.85 in kinnow + cantaloupe, 0.93 in chilli + kinnow, 0.94 in kinnow + tomato, than 0.96 in sole kinnow. This may be due to application of more supplemental doses of fertilizers, which maintained the tree vigour and nutrient status in the plant system i.e. no deficiency of nutrients in the plant will helped in timely maturation of the fruits.

The ascorbic acid was lower in mulched treatments 25.11 in kinnow + watermelon, 27.07 in kinnow + cantaloupe, 27.20 in chilli + kinnow, and 25.59 in kinnow + tomato, while in without

Table 3. Quality of kinnow mandarin fruits affected by mulched and without mulched intercrops

Treatments	TSS (%)		Juice (%)		Peel (%)		Acidity (%)		Ascorbic acid	
	Mulch	W/o mulch	Mulch	W/o mulch	Mulch	W/o mulch	Mulch	W/o mulch	Mulch	W/o mulch
T ₁	11.03	11.40	47.54	41.46	28.32	25.59	0.76	0.86	25.11	29.21
T ₂	11.07	11.50	46.98	39.80	29.01	25.78	0.81	0.85	27.07	29.49
T ₃	11.33	11.57	43.27	38.00	27.70	25.76	0.82	0.93	27.20	30.57
T ₄	11.30	11.57	41.98	37.86	27.12	24.94	0.84	0.94	25.59	30.98
T ₅	11.23	11.77	41.60	35.01	27.04	25.12	0.85	0.96	28.32	30.51
Mean	11.19	11.56	44.27	38.43	27.84	25.44	0.83	0.91	26.66	30.15
CD	0.19	0.30	1.36	2.11	1.49	NS	0.03	0.04	2.33	NS

mulched intercrops 29.21 in kinnow + watermelon, 29.49 in kinnow + cantaloupe, 30.57 in chilli + kinnow, 30.98 in kinnow + tomato, was lower than 30.51 in sole kinnow. The competition for solar radiation, moisture, nutrient and space are less in intercrops and kinnow plants, the selection of vegetable crops as intercrops under mulch conditions can be a viable option for farmers in grown up kinnow orchards.

4. CONCLUSION

From the above study we can conclude that the inter row space lying vacant can be utilized for growing seasonal vegetables. Watermelon, cantaloupe, chilli and tomato grown under mulch treatments positively influenced plant height, stem girth, canopy volume, number of fruits/tree, average fruit weight, yield and quality parameters (juice (%), peel (%), acidity (%), and ascorbic acid), while TSS was negatively influenced and better results were obtained in without mulch intercrops and sole kinnow plantation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Bhatnagar P, Kaul MK, Singh J. Effect of intercropping in Kinnow based production system. *Indian J. Arid Hort.* 2007;2:15-17.
- Swain SC. Performance and profitability study of different mango based intercropping systems in Eastern ghat high land zone of Odisha. *Journal of Crop and Weed.* 2014;10(2):170-178.
- Upadhyaya RC, Patiram, Ray S. Decline status of mandarin orange (*Citrus reticulata* Blanco) in Sikkim. *Journal of Hill Research.* 1994;7(2):83-88.
- A.O.A.C. 17th edn, Official method 942.15 Acidity (Titrable) of fruit products read with A.O.A.C official method 920. 149. Preparation of Test Sample; 2000.
- Pense VG, Sukhatme PV. Statistical methods for agricultural workers. IInd Ed. I.C.A.R. Agric. Circ. No. 1987;843.
- Soni BL, Birbal Saxena A, Nagaria V, Yadava ND. Intercropping with vegetables on productivity and economic returns of kinnow in arid region. *Indian J. Hort.* 2021;78(2):211-215.
- Yadava ND, Soni ML, Nathawal NS, Birbal. Productivity and growth indices of intercrops in agri-horti-silvi systems in arid Rajasthan. *Ann. Arid Zone.* 2013;52:61-65.
- Yadava ND, Soni ML, Rathore VS, Renjith PS. Performance of fruit trees (drip irrigation) and intercrops (rainfed) under agri-horti system in arid western Rajasthan. *Indian J. Arid Hort.* 2017;12:75-79.
- Shirgure PS. Effect of different intercropping systems on soil moisture conservation, fruit yield and quality of Nagpur mandarin (*Citrus reticulata*) in central India. *Sci. J. Agri.* 2012;1(7):168-176.
- Singh SK, Raghuvanshi M, Singh PK, Prasad J. Performance of vegetable crops as intercrops with guava plantation. *Res. Environ. Life Sci.* 2014;7(4):259-262.
- Pal PP, Tarai RK. Viable vegetable based intercropping system in Sweet orange cv. Mosambi. *Int. J. Adv. Res. Bio. Sci.* 2015;2:126-29.
- Arya R, Awasthi OP, Singh J, Singh IS, Manmohan JR. Performance of component crops in tree-crop farming system under arid region. *Indian J. Hort.* 2011; 68:6-11.
- Lachungpa K. Intercropping of agri/horti crops with special reference to mandarin (*Citrus reticulata* Blanco.) in Sikkim (INDIA). In: Australian Agronomy Conference; 2004.
- Abdel-Aziz RAA, Salem SE, Al-Bitar L. Effect of inter-cropping cover crops on citrus orchards growth and fruiting under Toshka conditions. *J. Agric. Vet. Sci.* 2008;1:101-110.
- B. Gouthami, M. Uma Devi M, K. Avil Kumar and V. Ramulu (2020). Influence of different nitrogen and potassium fertigation levels on economics of capsicum (*Capsicum annum* var. *grossum* L.) under poly house under poly house. *Chemical Engineering.* v01i01, 212- 216. <http://dx.doi.org/10.53709/CHE.2020.v01i01.031>
- Pandit S. Rathod, D.H. Patil, Yusufali A N, Shreenivas B V and Manjunath Patil (2020). Impact of Land Configurations and Irrigation Scheduling on Performance, Productivity and Profitability of hickpea Based Cropping System in Karnataka, India. *Chemical Engineering.* v01i01, 212-217. <http://dx.doi.org/10.53709/CHE.2020.v01i01.033>
- Raju Gupta, Traloki Singh, Thenua OVS. The Effect of Cropping System on

Different Fertility Levels and Grain Yield of Wheat under Irrigated Conditions, Chemical Engineering. 2020;v01i01:10–14.

Available:<http://dx.doi.org/10.53709/CHE.2020.v01i01.002>

18. Khursheed Alam and Muzeev Ahmad. Utilization of Heterosis in Cucurbit Vegetable Crops. Agriculture Archives. 2022;v1i1;19-22.

Available:<https://doi.org/10.5281/zenodo.6723604>

© 2022 Kumar et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:

<https://www.sdiarticle5.com/review-history/85383>