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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 320-327

www.thepharmajournal.com
Received: 25-04-2023
Accepted: 28-05-2023

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Effect of some antitranspirants and trickle irrigation intervals on water status, nutrient content and yield of Kinnow mandarin (*Citrus reticulate* Blanco) under sandy loam soil

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Abstract
Scarcity of water is the major causes of lower productivity and decline of Kinnow mandarin orchards in subtropics. With a hypothesis that the combination of optimal amount of water and some antitranspirants application through trickle irrigation (TI) and foliar application (FA) could save substantial irrigation and transpiration loses of water comparative to that under alone trickle irrigation intervals and antitranspirants this study was conducted in Kinnow mandarin in sandy loam soil of north-west of India. This study involved two irrigation intervals (3 and 6day) under trickle irrigation system, with spraying by two antitranspirant substances (Kaolin 2% and 4% and magnesium carbonate ($MgCO_3$) 2% and 4), which subjected in a randomized block design with three replications. The analysis of plant leaf lesser concentration of major (N, P, K) and secondary (Ca and Mg) nutrients observed that control treatments. The total water content (TWC), leaf water deficit (LWD), total chlorophyll (TC) and Leaf area (LA) showed an increasing trend under two year investigation. The maximum fruit yield (20.20- 21.35 kg per tree) was recorded with 3 days intervals water supply by trickle irrigation with foliar spray of magnesium carbonate (4%) in treated plants.Generally, these results disclose that 3 days trickle irrigation intervals with Kaolin (4%) could endorse the necessary water pressure on 'Kinnow' mandarin plants of sandy loam soil of subtropical ecosystem enlightening their water productivity and fruit yield in water scarce situation.

Keywords: Kinnow mandarin, drip irrigation, antitranspirants, kaolin, rainfed condition

Introduction
Citrus is one of the most important kinds of fruit, which has economic advantages among other fruit types. It is careful the first popular fruit in India due to its high nutritional value, cheap prices and the international reputation in the foreign markets for its outstanding fruit qualities. Kinnow mandarin is gaining commercial importance due to its good yield, high processing quality, fresh consumption aromatic flavor and better adaptation to agro-environmental conditions as well as its multifold nutritional and medicinal values besides excellent desert quality, characteristic aroma, pleasant and outstanding appearance, relatively less granulation, precocious bearing habit and adaptability to even adverse weather conditions. In the union territory of Jammu and Kashmir, citrus is successfully grown in sub-tropical areas of Jammu division covering an area of about 14542 hectares with production of about 34191 MT (Anonymous, 2017) [1]. Jammu province mostly comprises of *kandi* belt, *Kandi* belt of Jammu is also known as sub-montane area which comprises the lower Shiwalik region. In this areas are the major constraints of soil moisture stress, poor soil fertility and unpredictable rainfall configuration. In this region, the water table is very deep and no irrigation facilities as well as no moisture conservation in fruit growing orchards. Soil moisture and leaf water balance is one of the most important aspects of surviving condition of fruit growing orchards and development of fruit quality attributes. Later, proper soil moisture management and antitranspirants by optimum use of available water resource is quite essential in this crop condition. The area under Kinnow is increasing at a faster rate due to wide range of adaptability, precocious bearing, high yield, excellent fruit quality and very high economic returns to the growers. Kinnow mandarin is commercially cultivated due to its good yield, high processing quality, fresh consumption, aromatic flavour and better adaptation to agro-environmental conditions (Sharma *et al*. 2012) [2].

Trickle irrigation is one of the most important potential water saving techniques in citrus (Panigrahi *et. al*., 2012) [3]. Drip irrigation is a new concept and it has also increasing plant vegetative growth, leaf area, fruit production and fruit quality in citrus cultivars pera orange (Pires *et. al*., 2016) [4].

Antitranspirants are the chemical compound which results in declining the respiration rate from the leaves of the plants by reducing the number and size of the stomata and eventually hardening them to stress. It is very important to control the loss of the water from the plant because only a very small amount of water taken up by the roots, out of which 98% is lost to the atmosphere through transpiration. Antitranspirants helps in minimizing these losses to some extent. The role of antitranspirants increases in rainfed/dryland horticulture where availability of water is very less and the temperature is very high which promotes the rate of transpiration. They are also known as transpiration suppressant agents. Antitranspirants were grouped into three categories, namely film-forming types; which coat leaf surface with films that are impervious to water vapor (Mobileaf, hexadeconol and silicon), reflecting materials; which reflect back a portion of the incident radiation falling on the upper surface of the leaves (Kaolin, calcium bicarbonate and China clay) and stomatal closing types; which affect the metabolic processes in leaf tissues (Phenyl mercuric acetate and ABA. Based on the mode of their action, they are categorized into: stomatal closing type (Phenyl mercuric acetate and ABA), film forming type (Mobileaf, hexadeconol and silicon), reflectant type (Kaolin, calcium bicarbonate and China clay) and growth retardants (cycocel).

Kaolin (surround WP) is a non-abrasive, non-toxic aluminosilicate (Al4Si4O10 (OH) 8) clay mineral that has been formulated (Engelhard Corporation, Iselin, NJ) as a wettable powder for applicatio n with conventional spray equipment (Cantore *et al*., 2009) [5]. A reflective Kaolin spray was found to decrease leaf temperature by increasing leaf reflectance and to reduce transpiration rate more than photosynthesis in many plant species grown at high solar radiation levels (Nakano *et al*., 1996) [6]. Reflecing antitranspirants were found that to be non-toxic and have effectiveness in longer period than metabolic types (Gawish, 1992) [7]. Magnesium carbonate ($MgCO_3$) is considered to be an antitranspirant that closes stomata and thus affects metabolic processes in leaf tissues (Soha *et. al*., 2012) [8]. Magnesium carbonate ($MgCO_3$) is an antitranspirant, which induces stomatal closing and enhances plant growth and physiology. In this study, effect of foliar application of $MgCO_3$ at 1 and 3% on plant resistance, growth, yield and physiology of grapevines (cv. King Ruby seedless) infected with downy mildew was investigated under yield conditions. Spraying magnesium carbonate ($MgCO_3$) at 5% as antitranspirant and irrigate banana plants at 60% of the available water depletion is the promising treatment to reduce the total amount of irrigated water through the growing season of Wiliams banana plants, both antitranspirants (magnesium carbonate) and kaolin (aluminum silicate) improved yield (kg/tree) specially.

Antitranspirants minimises transpirational losses, so that limited amount of the soil moisture can be utilised by the plants for completing the life cycle of the crop plant. Antitranspirants along with slowing down the rate of transpiration also reduces the photosynthesis efficiency of the crop plant due to less uptake of the carbon dioxide through the narrowed aperture of the stomata, comparatively less permeability of carbon dioxide through the film and rise in leaf temperature. Moreover, most importantly use of antitranspirants results in reducing water and drought stress, retaining more water in the leaves and therefore tremendously improved the water use efficiency (WUE) of the plants. Moreover, the information available on citrus production under drip/trickle irrigation and antitranspirants in sandy loam soil is very limited in worldwide. Consequently it has been acknowledged that the plant itself is the best needle of water stress and fruit yield (Panigrahi *et. al*., 2014) [9], first-hand approach for estimating fruit yield consuming plant-based measurements of 'Kinnow' mandarin might also profits fruit growers communities. Keeping in view, the present study was carried out with following objectives: (i) to optimize the drip/trickle irrigation and antitranspirants in relation to fruit yield and physical parameters of 'Kinnow' mandarin and (ii) to develop the plant nutrient content and physiological evolution in water stress rainfed condition on sandy loam soil in subtropical climate of northern India.

Materials and Methods

Experimental site: The field experiment was conducted at 10 years old plants of Kinnow mandarin which were planted in the farmer field of Rahya village, tehsil- Vijaypur, district- Samba, Jammu and Kashmir, India. The experiment was conducted for two consecutive years (2018-19 to 2019-20). The texture class of experimental site was sandy loam and soil reaction was almost neutral pH (7.05) with mild EC (0.248 dSm^{-1}) and organic carbon was low (4.48 g kg^{-1}). The mean available N, P, and K concentration in the soil was 198.9, 14.28 and 139.30 kg ha^{-1} soil respectively. The climate of the experimental site is characterized as subtropical climate with hot and dry in summer season, hot and humid in rainy season and cold in the winter months. The rainfall distribution patterns are particularly erratic in time and space leads to moisture stress condition during the major part of the year.

Treatments and layout: The experiment was laid out randomized block design with 15 treatments and 3 replications considering one tree as unit to characterize one treatment. The treatment details are T_1 –Control, T_2- 3 days drip/ trickle irrigation, T_3- 6 days drip/ trickle irrigation, T_4- Kaolin (2%), T_5- Kaolin (4%),T_6- $MgCO_3$(2%), T_7- $MgCO_3$(4 %),T_8- 3 days drip/trickle irrigation with Kaolin 2%, T_9- 6 days drip/trickle irrigation with Kaolin 2%, T_{10}- 3 days drip/trickle irrigation with Kaolin 4%, T_{11}- 6 days drip/ trickle irrigation with Kaolin 4%, T_{12}- 3 days drip/ trickle irrigation with $MgCO_3$(2%), T_{13}- 6 days drip/ trickle irrigation with $MgCO_3$ (2%), T_{14}- 3 days drip/ trickle irrigation with $MgCO_3$ (4%) and T_{15}- 6 days drip/ trickle irrigation with $MgCO_3$ (4%). All the measurements were taken from the experiment trees.

Water applied and crop management practices: The drip /trickle irrigation water supplied during 15th march to 15th July in summer season as well as winter season was supplied on 15th September to 15th October in the water stress period. Two litre bottle filled in the tap water and has adjust the drip in minimum rate of 2 litre water per 4 hours was imposed in the root zone of the plant. The orchard floor was kept cleaned and all the experimental trees were grown under uniform cultural and management practices. The fertilizer (1600g N as both urea and diammonium phosphate, 345g P_2O_5 as diammonium phosphate and 250g K_2O as Muriate of potash per plant) was applied in the month December in a year, as recommended for bearing Kinnow plants (Anonnymous 2017) [1]. Ground floor of the experimental orchard was kept weed free and uniform plant protection measures against insect pests and diseases were adopted for all plants in the experimental block.

Measurements and analysis: The soil samples were analyzed for soil properties and available macro-nutrients i.e. soil pH, EC, organic carbon, available nitrogen, available phosphorus and available potassium by standard procedure (Jackson, 1973) [10] after harvest of the fruit crop. One plant basin from each replicated plot (3 experimental plants per treatment) was taken for soil sampling. The three to five months old leaf samples (3rd and 4th leaf from tip of non-fruiting branches) at a height of 1.5 to 1.8 m from ground surface surrounding the plant canopy were collected at the end of October, as recommended by (Chahill, 1998) [11] and analyzed for macro-nutrients (N, P and K) and secondary nutrients (Ca and Mg) following the standard procedures suggested by (Tandon, 2005) [12]. Total chlorophyll content was measured by using chlorophyll meter SPAD-502. The randomly selected 8 in fresh leaves in a plant and calculate the average value.
Spraying with antitranspirants was done three times: the month of April, May and June at the peak season of summer and recorded the following measurements:
Water status of the plants:

(a) Total water content (TWC) of the leaves: it was registered after 2nd day of the third spraying of antitranspirants using the following equations:

$$TWC\ \% = (\text{wet weight-dry weight}) / \text{wet weight} \times 100 \quad (1)$$

(b) Leaf water deficit (LWD): it was estimated by weighing a plants leaves token randomly at the early morning (wet weight); then placed on the surface of distilled water for 1 h until saturated and then weighed again (saturated weight); then dried in oven and weighed (dry weight). The dry weight was determined by placing the leaflets in an oven at 60^0 C for 1-2 days until a constant weight had been achieved. The LWD was calculated as follows:

$$LWD\ \% = (\text{saturated weight- wet weight}) / \text{saturated weight- dry weight}) \times 100 \quad (2)$$

To study the leaf area, eight mature leaves in one plant replicated three times were abscised in December, then leaf area (cm^2) was calculated according to the following equation by (Ahmed *et al*., 1999) [13].

$$LA = 0.49\ (L \times W) + 19.09 \qquad (3)$$

Where, LA is leaf area (cm^2), L is the maximum leaf length (cm), W is the maximum leaf width (cm).
The fruits were harvested in the middle of December. The number and weight of total fruit from each experimental tree under various treatments was recorded and the mean yield per tree was predictable. After the harvest, five fruits per experimental tree were taken randomly.

Statistical analysis
All the data generated were subjected to analysis of variance (ANOVA) and the least significant difference (LSD) at 5% probability level was obtained with help of SPSS 16.0.

Result and discussion
Leaf physiological parameters
Table-1 shows the effect of drip/trickle irrigation intervals and antitranspirants on leaf chlorophyll and water status of Kinnow mandarin. The increases in trickle irrigation intervals from 3to 6 days with some antitranspirants led to a significant improve in the total chlorophyll content and total water content of leaves. The total chlorophyll was observed in maximum of T10 treatment followed by T14, T11 and was minimum T1 (control). The total chlorophyllcontent was reducing under advanced water stress, they expected that moisture stress would have prevented the biosynthesis of chlorophyll a predecessor, which in turn would have declined the total chlorophyll content that also reproduce mineral content (Prakash and Ramachandra, 2000 [14]; Kumar *et al*., 2022 [15]).The total water content highest in T10 treatment followed by T14, T11, and T12 was minimum in T1. Similarly LWD was highest in T10 followed by T14, T11 and T15 treatments. The decrease in total water content (TWC) and leaf water deficit (LWD) of the leaves with 6 day when prolonged the irrigation intervals which might be due to low content of soil moisture especially in the surface layer of soil (0-20 cm), where the distribution of most roots are found in this zone could lead to exposure the plant to water stress and reduce the efficiency of water absorption through plant roots and thus lead to a decline in the TWC and LWD of the leaves. These finding are agreement with the (Khalel, 2015) [16].

Table 1: Leaf water status, leaf area and total chlorophyll of Kinnow mandarin under different treatments

Treatment	Total Chlorophyll		TWC (%)		LWD (%)		Leaf area (cm)	
	2019	2020	2019	2020	2019	2020	2019	2020
T1	37.86	37.94	52.46	52.48	19.88	19.92	36.32	36.33
T2	38.53	38.60	53.78	53.80	20.72	20.75	37.61	37.78
T3	38.22	38.30	52.98	53.02	20.22	20.44	36.92	37.61
T4	39.80	39.88	54.25	54.30	21.12	21.16	38.9	39.6
T5	40.66	40.76	55.16	55.20	22.00	22.05	39.32	40.12
T6	40.08	40.10	54.48	54.50	21.28	21.20	36.73	37.38
T7	41.45	41.52	55.72	55.78	22.12	22.16	37.46	38.16
T8	41.74	41.82	56.32	56.35	23.24	23.27	40.42	40.82
T9	41.18	41.22	56.12	56.15	22.64	22.68	38.79	39.62
T10	44.65	44.76	58.45	58.50	25.08	25.12	44.92	45.56
T11	43.58	43.57	57.18	57.92	24.38	24.31	43.52	43.73
T12	41.94	42.03	56.18	56.20	23.13	23.15	39.98	41.06
T13	41.26	41.30	56.00	56.04	22.82	22.55	37.88	38.49
T14	43.86	44.56	58.12	58.15	24.54	24.52	43.62	43.86
T15	43.38	43.44	57.30	57.70	24.28	24.16	41.83	42.55
Sem (±)	0.260	0.290	0.180	0.200	0.110	0.120	0.12	0.13
CD (P=0.05)	0.750	0.836	0.515	0.572	0.310	0.338	0.36	0.37

Data in one column followed by different letters are significantly different at (LSD, $p < 0.05$).

As for the role of antitranspirants (Kaolin and magnesium carbonate) in increasing the total water content and leaf area and leaf water deficit, it may be due to the activity of this substances in reflective type and partial closing of stomata, which helps in decrease the temperature by increasing leaf reflectance and decreasing the rate of transpiration and reducing water loss through stomata containing are reflective kind and stomata closes. The foliar spray of antitranspirant *viz*. Kaolin with trickle irrigation affected by leaf area of the plants significantly in the treatment T10. The better value of T10and was the lower value of T1in both years. The better value may be due to increase in soilmoisture content in the root zone, so improving growth, created maximum canopy volume in navel orange (Abobatta *et al*., 2019) [17]. The influence of antitranspirants ($MgCO_3$ and Kaolin) in TWD, LWD and leaf area is recognize through improving water potential of the plant leaf in the stage that plant growth support on the water status more than photosynthesis (Gaafar and Ayoub, 2018) [18]. The increase in the growth will produce a good leaf area which stimulates photosynthesis. Similar results are reported by Khalel (2015) [16].

Changes in soil properties and available nutrients

The concentration of organic carbon and available N, P, K in soil showed differential responses to trickle irrigation intervals and some antitranspirants of treated Kinnow mandarin (Table -2). The soil pH and EC was higher under treatment T14 followed by T15, T12, T13, T10 while lowest was recorded in T1 (figure 1 &2). Similarly, the organic carbon of T14 was higher and was lowest in T1. Amongst the combination treatment of water supply through trickle irrigation intervals and some antitranspirants in the root zone of the plants under better response.

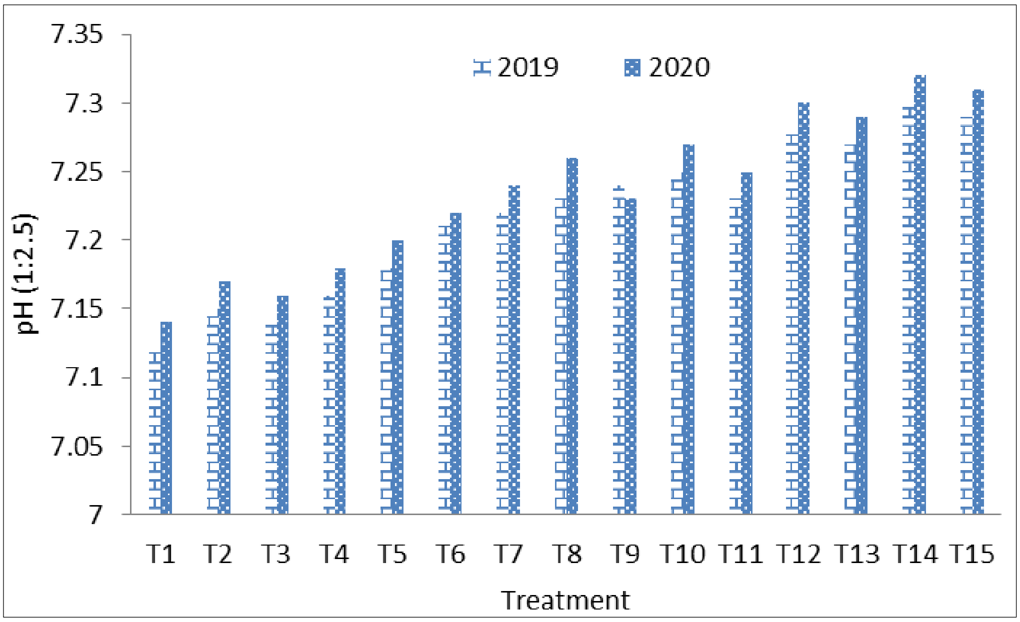

Fig 1: Soil pH (1:2.5) of Kinnow mandarin under different treatments

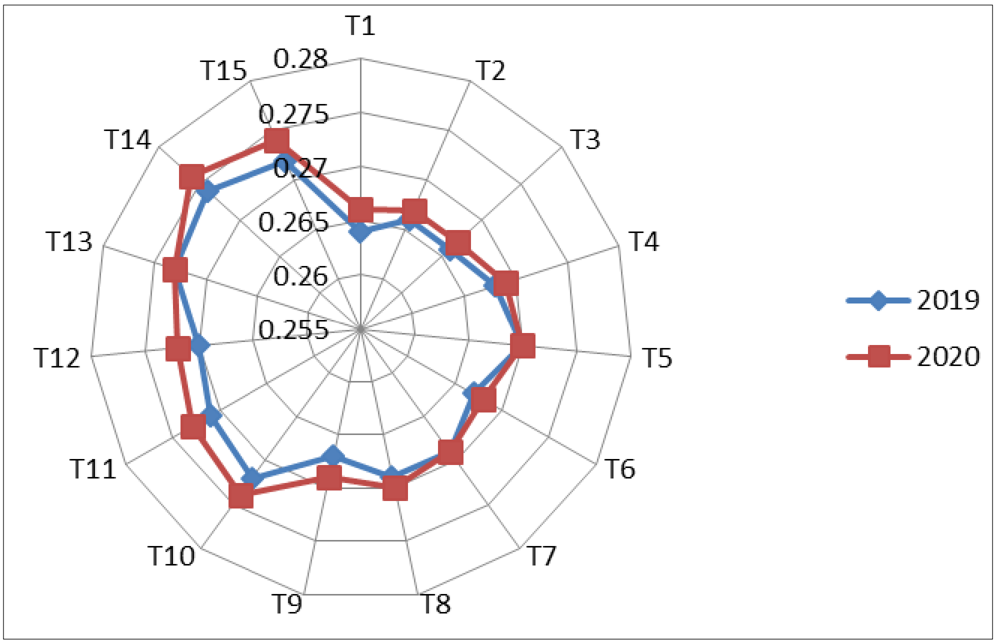

Fig 2: Electrical conductivity (EC dSm^{-1}) of Kinnow mandarin under different treatments

The available macro-nutrients *viz.* nitrogen, phosphorus, potassium were observed in the higher in T14 followed by T10 and T15 while lowest was observed in T1. The improve available macro-nutrient content in soil which might be due to leaching loss of nutrient and retain water and nutrient in soil which in turn changes the soil microbial communities and redox potential and thus also affect the nutrient status of soil (Kumar *et al.*, 2022) [19]. Conversely, the effect of water supply through trickle irrigation on soil pH, EC and available P was statistically not significant due to lethargic progress (Amberger, 2006 [20]; Kumar *et al.*, 2022) [21]. The improved in available nutrient concentration was superior in 2020 than 2019, illustrative superior nutrients uptake by tree in the former year.

Table 2: Changes in soil organic carbon and available nutrients of Kinnow mandarin under different treatments

Treatment	OC (g kg^{-1})		Available nutrients (kgha^{-1})					
			Nitrogen		Phosphorus		Potassium	
	2019	2020	2019	2020	2019	2020	2019	2020
T1	4.42	4.44	208.42	210.12	14.12	14.26	144.12	1.46.24
T2	4.44	4.46	210.45	212.16	14.74	14.82	147.16	148.56
T3	4.44	4.44	210.84	212.76	14.52	14.58	146.24	147.52
T4	4.48	4.49	211.48	213.24	15.42	15.48	149.56	151.12
T5	4.5	4.51	212.54	213.72	15.84	15.86	150.14	152.78
T6	4.49	4.48	212.84	214.02	15.92	15.98	151.42	153.12
T7	4.51	4.52	213.78	215.12	15.98	16.04	153.28	155.89
T8	4.49	4.5	212.85	213.78	15.68	15.72	155.24	156.74
T9	4.48	4.49	212.24	213.12	15.54	15.62	154.14	155.45
T10	4.53	4.54	213.42	214.78	16.02	16.14	156.28	156.78
T11	4.51	4.52	212.96	213.96	15.72	15.76	155.78	156.46
T12	4.50	4.52	213.42	214.24	16.04	16.18	153.24	157.26
T13	4.49	4.50	212.56	213.77	15.85	16.02	153.02	157.04
T14	4.52	4.53	214.36	215.42	16.25	16.28	156.28	158.34
T15	4.50	4.51	213.12	215.04	16.12	16.16	154.12	157.36
Sem (±)	0.010	0.011	0.112	0.114	0.012	0.013	0.102	0.106
CD (P=0.05)	0.028	0.031	0.332	0.342	0.033	0.038	0.306	0.316

Data in one column followed by different letters are significantly different at (LSD, $p< 0.05$).

Leaf nutrients composition

The major and secondary nutrients (N, P, K Ca and Mg) concentration in leaves revealed that inequality response to some antitranspirants and trickle irrigation intervals treatments (Table 3). The available major nutrients like nitrogen, phosphorus and potassium were observed in the superior of T14 followed by T15, T12, and T13 while lowest was recorded in T1. The accumulation of superior leaf nutrient concentration might be due to recognised to least wee population under trickle irrigation and some antitranspirants as accessibility of more nutrients in soil and leaf content for improved growth and their translocation to the leaves of the trees (Kim *et al.*, 2008 [22];Kumar *et al.*, 2022) [23]. The movement of leaf nutrients concentration with the composition of the effect of water stress of Kinnow mandarin under citrus species (Kumar *et al.*, 2021) [24].

Table 3: Leaf nutrients (N, P, K, Ca and Mg) composition of Kinnow mandarin under different treatments

Treatment	Nitrogen %		Phosphorus %		Potassium %		Calcium %		Magnesium %	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T1	2.256	2.254	0.099	0.101	1.369	1.377	1.611	1.614	0.378	0.380
T2	2.274	2.276	0.119	0.120	1.376	1.383	1.628	1.632	0.386	0.389
T3	2.266	2.268	0.106	0.110	1.372	1.381	1.621	1.625	0.382	0.384
T4	2.308	2.304	0.119	0.122	1.378	1.390	1.634	1.638	0.388	0.390
T5	2.326	2.328	0.130	0.127	1.399	1.401	1.645	1.649	0.392	0.394
T6	2.318	2.314	0.134	0.133	1.389	1.395	1.638	1.642	0.390	0.391
T7	2.342	2.346	0.138	0.137	1.412	1.418	1.652	1.658	0.406	0.408
T8	2.412	2.416	0.146	0.145	1.442	1.447	1.642	1.645	0.388	0.392
T9	2.395	2.404	0.132	0.140	1.428	1.427	1.636	1.640	0.385	0.389
T10	2.558	2.564	0.155	0.152	1.462	1.465	1.651	1.660	0.399	0.403
T11	2.468	2.470	0.144	0.148	1.454	1.456	1.648	1.655	0.394	0.396
T12	2.432	2.444	0.152	0.155	1.438	1.442	1.648	1.648	0.415	0.418
T13	2.489	2.494	0.148	0.147	1.432	1.435	1.643	1.646	0.420	0.422
T14	2.568	2.572	0.163	0.165	1.568	1.572	1.669	1.674	0.424	0.428
T15	2.534	2.536	0.155	0.158	1.552	1.564	1.660	1.670	0.419	0.423
Sem (±)	0.009	0.010	0.002	0.002	0.002	0.003	0.004	0.004	0.001	0.002
CD (P=0.05)	0.026	0.029	0.005	0.006	0.006	0.009	0.011	0.011	0.003	0.006

Data in one column followed by different letters are significantly different at (LSD, $p< 0.05$).

The superior primary nutrient of nitrogen, phosphorus and potassium concentration in leaves of 3 days water supply through trickle irrigation intervals and some antitranspirants were increase the availability of such nutrients in leaf and soil as compared to alone treatments. The content of nutrients in Ca and Mg under leaves was higher in T14 followed T15 and was lowest in T1. The better noteworthy augmentations of N, P, K Ca and Mg content in the leaves than the untreated tree in both years. In this respects foliar spraying of Mg CO_3 was superior treatment followed by kaolin. On the other way, untreated tree recorded the lowest nutrient concentrations in both years. The response of foliar spray of some antitranspirants observed the better uptake of all nutrients as compared to control. The greater increase in leaf nutrients status suggests for combination of foliar spray of antitranspirants ($MgCO_3$ and Kaolin) with trickle irrigation intervals as compared to sole trickle irrigation and antitranspirants for Kinnow mandarin orchards in the study region.

Fruit yield and quality parameters

The influence of trickle irrigation intervals and some antitranspirants on fruit yield and quality parameters (Number of fruit tree^{-1}, Fruit length, Fruit breadth, Fruit weight, Fruit volume) are presented in Table 4. The fruit yield was maximum in T10 followed by T14, T11 T15 and whereas lowest in T1 (Fig. 3).

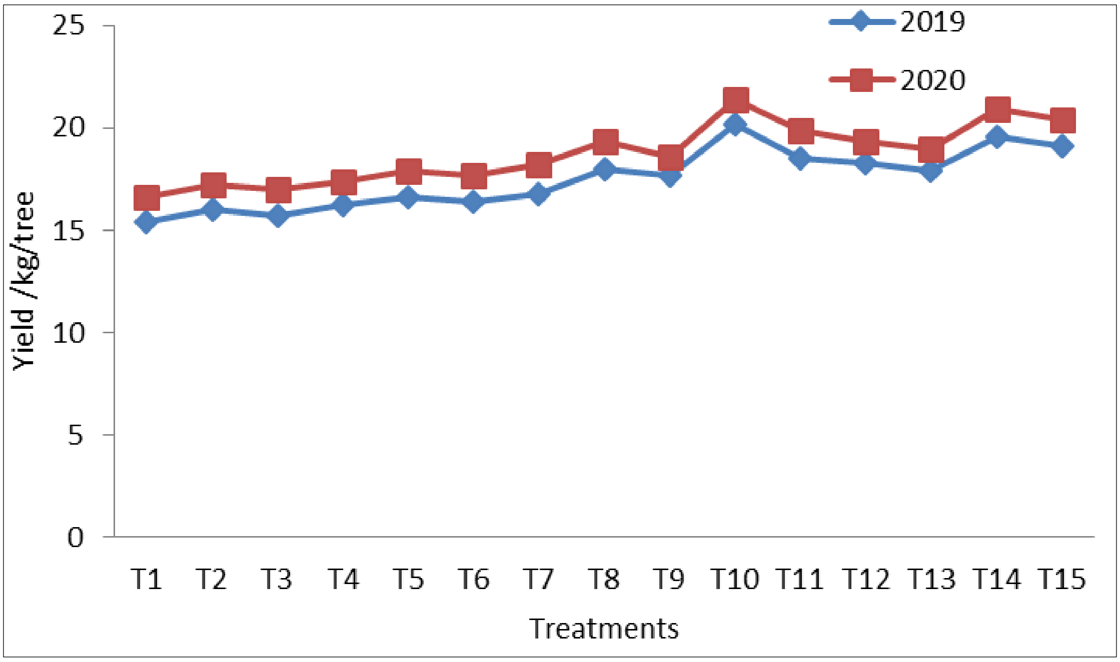

Fig 3: Fruit yield of Kinnow mandarin under different treatments

The maximum number of fruit per tree, fruit weight and total fruit yield improve with increase in tickle irrigation intervals and application of some antitranspirants from T10. The highest fruit length and breadth were superior in T10 followed by T14, T11, T15 and were lowest in T1. The lesser in fruit length, breadth, and fruit weight in T1 treatment could be due to without the treated trees. The fruit volume was higher in T10 followed by T14, T11, T15 while lowest in without treated treatment T11.

Table 4: Fruit yield, fruit weight and fruit volume of Kinnow mandarin under different treatments

Treatment	No. of fruit		Yield /kg/tree		Fruit length (cm)		Fruit breadth (cm)		Fruit weight (g)		Fruit volume (cc)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T1	150.63	160.85	15.40	16.60	6.15	6.20	6.87	6.89	102.24	103.20	105.52	106.20
T2	154.62	163.34	16.00	17.20	6.24	6.27	6.92	6.93	103.48	105.30	106.28	106.98
T3	152.06	162.45	15.70	17.00	6.20	6.24	6.90	6.91	103.25	104.65	106.00	106.25
T4	156.04	163.69	16.20	17.40	6.27	6.29	6.94	6.96	103.82	106.30	107.54	107.80
T5	159.10	167.04	16.60	17.90	6.35	6.36	6.98	6.99	104.34	107.16	108.24	108.50
T6	157.31	166.43	16.40	17.70	6.29	6.32	7.02	7.03	104.25	106.35	107.78	108.08
T7	159.82	169.65	16.80	18.20	6.38	6.40	7.05	7.07	105.12	107.28	108.84	109.18
T8	169.27	178.41	18.00	19.30	6.42	6.43	7.12	7.14	106.34	108.18	109.45	109.82
T9	167.58	172.35	17.70	18.60	6.40	6.41	7.09	7.11	105.62	107.92	109.04	109.41
T10	186.62	193.48	20.20	21.35	6.55	6.57	7.39	7.41	108.24	110.45	111.52	112.12
T11	172.66	182.37	18.50	19.90	6.51	6.53	7.28	7.30	107.15	109.12	110.55	110.82
T12	171.86	177.77	18.30	19.35	6.45	6.47	7.18	7.19	106.02	108.33	109.84	110.88
T13	168.36	175.14	17.90	18.95	6.43	6.45	7.16	7.17	106.32	108.20	109.12	111.52
T14	181.35	189.79	19.60	20.90	6.52	6.54	7.36	7.38	108.08	110.32	111.14	111.54
T15	177.58	185.93	19.10	20.40	6.49	6.50	7.25	7.26	107.56	109.72	110.48	110.42
Sem (±)	0.762	0.778	0.238	0.245	0.035	0.038	0.021	0.024	0.278	0.282	0.035	0.038
CD (P=0.05)	2.220	2.260	0.693	0.715	0.101	0.109	0.057	0.065	0.806	0.817	0.101	0.110

Data in one column followed by different letters are significantly different at (LSD, $p< 0.05$).

The superior fruit yield and its physical properties like fruit weight, number of fruits and fruit volume is related to weed free environment, maximum soil moisture and higher nutrient uptake under trickle irrigation intervals and some antitranspirants of kaolin and magnesium carbonate in treated plants of Kinnow mandarin orchards. Similar results are reported by (Desouki *et al*., 2009 [25]; Kumar *et al*, 2016 [26])

Conclusion

This study shows that variation in wetting patterns under trickle irrigation and some antitranspirants caused significant differences in leaf water status, nutrient composition and fruit yield of sandy loam soils in the production of Kinnow mandarin orchards. Trickle irrigation is the best option for improving productive and water saving techniques in rainfed conditions. The uses of antitranspirants in summer season reduce the water loss through transpiration as the output of partial closer of stomata. The substantial trickle irrigation intervals with Kaolin (4%) followed by $MgCO_3$ resulted in important of soil fertility and higher fruit yield. The effect of antitranspirant *viz* Kaolin (4%) with 3 day trickle irrigation intervals on improving of water status was higher in LWD (%) and TWC (%) than that $MgCO_3$ with 3 day trickle irrigation treatment. Based on these results, it can be liable the foliar application of Kaolin (4%) with three days trickle irrigation might better option for 'Kinnow' mandarin cultivation in water scarcity of northern India and away having comparable agro-climatic condition. This could help in bringing more area under antitranspirants with trickle irrigation might be used for water lacking in rainfed conditions for upsurge in the production of citrus with prolonged orchard permanence.

Acknowledgement

The authors are thankful to the Directorate of Research, SKUAST-J for providing the financial support and Head, Division of Soil Science and Agricultural Chemistry, for laboratory facilitates in soil and leaf analysis as well as Division of Plant Physiology for FOA, Chatha is gratefully acknowledged of Sher -e- Kashmir University of Agricultural Sciences and Technology - Jammu.

References

1. Anonnymous. Package of practices for horticultural crops. Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India; c2017.
2. Sharma T, Khan MK, Misra P, Shukla PK. Micropropagation of Kinnow through nodal explants. The Bioscan. 2012;7(2):295-297.
3. Panigrahi P, Srivastava AK, Huchche AD, Singh S. Plant nutrition in response to dripver susbas in irrigation in young Nagpur mandarin on Inceptisol. J. PlantNutr. 2012;35:215–224.
4. Pires RCDEM, Junior DB, Sakai E, Villar HL, Silva TJAD, Arruda FB. Effect of trickle irrigation on root development of the wet bulb and 'pera' orange tree yield in the state of Sao Paulo, Brazil. Eng. Agric. Jaboticabal. 2016;31(6):1096-1103.
5. Cantore V, Pace B, Albrizio R. Kaolin-based particle film technology affects tomato physiology, yield and quality. Environmental and Experimental Botany. 2009;66:279-288
6. Nakano A, Uehara A. The Effect of Kaolin Clay on Cuticle Transpiration in Tomato. Acta Horticultural. 1996; 440:233-238.
7. Gawish R. Effect of Antitranspirants Application on Snap Bean (*Phaseolus vulgaris* L.) Grown under Different Irrigation Regimes. Minufiya J. Agric. Res. 1992;17:1309-1325.
8. Soha E, Khalil SE, Mohamed M, Hussein J da, Silva AT. Roles of Antitranspirants in Improving Growth and Water Relations of Jatropha curcas L. Grown under Water Stress Conditions. Plant Stress. 2012;6(1):49-54.
9. Panigrahi P, Sharma RK, Hasan M, Parihar SS. Deficit irrigation scheduling and yield prediction of Kinnow mandarin (Citrus reticulate Blanco) in semiarid region. Agric. water manage. 2014;140:48-60.
10. Jackson ML. Soil chemical analysis: Advanced course. The Author. Madison, Wisconsin, USA. 1973.
11. Chahill BS, Dhatt AS, Singh R. Standardization of foliar sampling tech-niques in kinnow mandarin. Punjab Hort.J. 1988;20:118-129.
12. Tandon HLS. Methods of Analysis of Soils, Plants, Waters, Fertilizers and Organic Manures, seconded. Fertilizer Development and Consultancy Organization, New Delhi, India; c2005.
13. Ahmed FF, Morsy MH. A new method for measuring leaf area in different fruit species. Minia Journal of Agricultural Research and Development. 1999;19:97-105.
14. Prakash M, Ramachandran K. Effect of moisture stress and antitranspirants on leaf chlorophyll. Journal of Agronomy of crop Science. 2000;184:153-156.
15. Kumar V, Kumar R, Chand G, Kumar J, Singh B, Dhotra B, Khajuria S, Gupta S, Sharma N, Sinha AK, Raina V, Ahamad S. Influence of trickle irrigation and hydrogel on Kinnow mandarin (Citrus reticulate Blanco) under rainfed condition. Agricultural Mechanization in Asia. 2022;53(7):9007-9023.
16. Khalel AMS. Effect of drip irrigation intervals and some antitranspirants on the water status, growth and yield of potato (*Solanum tuberosum* L.) Journal of Agricultural Science and Technology. 2015;5:15-23.
17. Abobatta WF, Khalifa SM. Influence of hydrogel composites soil conditioner on navel Orange grow than d productivity. J. of agric. And hortic. Res. 2019;2(2):1-6.
18. Gaafar MSA, Ayoub FH. (2018). Effect of irrigation intervals and some antitranspirants on growth and yield of snap bean (*Phaseolus vulgaris* L.) under drip irrigation systems in clay loam soil. *Menoufia Journal Production 2018;*3: 319-333.
19. Kumar V, Kumar R, Chand G, Kumar J, Singh B, Khajuria S, Dhotra B, Reena, Sharma A, Kumar M. Dynamics of soil properties and fruit productivity of Kinnow mandarin (Citrus reticulate Blanco) as affected by drip trickle irrigation and hydrogel. Agricultural Mechanization in Asia. 2022;53(3):6439-46.
20. Amberger A. Soil Fertility and Plant Nutrition in the Tropics and Subtropics, first ed.IFA/IPI, Paris, France/ Horgen, Switzerland; c2006.
21. Kumar V, Chand G. Impact of drip/trickle irrigation and hydrogel with mulch on nutrient status, yield and quality of Kinnow mandarin. Journal of Soil and Water Conservation. 2022;21(3):293-298.

22. Kim EJ, Choi DG, Jin SN. Effect of preharvest reflective mulch on growth and fruit quality of plum (*Prunus domestica* L.). Acta Horticulturae. 2008;772:323-326.
23. Kumar V, Kumar R, Singh VB, Sinha BK, Singh P, Raina V *et al*. Economic evaluation of Kinnow mandarin (Citrus reticulate blanco) as affected by drip irrigation and some antitranspirants under rainfed condition. Indian Journal of Agriculture and Allied Sciences. 2022;8(4):87-91.
24. Kumar V, Kumar R, Singh VB, Chand G, Kumar J, Singh B *et al*. Productivity and water use efficiency of kinnow mandarin (citrus reticulate blanco) as influenced by drip trickle irrigation and hydrogel. Annals of Plant and Soil Research. 2021;23(3):363-367.
25. Desouki MIA, El-Rhman IEA, Sahar AF. Effect of some antitranspirants and Supplementary irrigation on growth, yield and fruit quality of Sultani Fig (*Ficus Carica*) Grown in the Egyption Western Coastal Zone under Rainfed condtions. Research Journal of Agriculture and Biological Sciences. 2009;5(6):899-908.
26. Kumar V, Sharma V, Bhat AK, Gupta N, Singh VB. Effect of Various Mulching on Soil Properties and Fruit Quality Attributes of Eureka Lemon (*Citrus limon* Burm) in Kandi Area. Ind. J. Ecology. 2016;43(1):238-241.
27. Ebid WM, Mabrouk AM. Physicochemical and microbiological properties of functional Labneh fortified with mandarin peel powder during refrigeration storage. Int. J. Food Sci. Nutr. 2022;7:46-53.