

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.910.243>

Influence of Organic and Inorganic Mulches on Yield and its Attributes of Khasi Mandarin (*Citrus reticulata* Blanco) in Foothill Region of Nagaland

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ABSTRACT

Keywords

Khasi Mandarin,
Mulching, Yield,
Fruit weight, Fruit
quality

Article Info

Accepted:
15 September 2020
Available Online:
10 October 2020

A field experiment was carried out in 15-years old Khasi Mandarin trees growing in the farmer's field in mid-hill regions of Mokokchung District of Nagaland during the year 2016-18. Completely Randomized Design (CRD) with three number of replications was employed for nine treatments using organic mulches viz., 5cm thick layer of rice husk, saw dust, chopped banana leaves and pseudo-stem, FYM, forest leaves & rice straw above the soil surface around the tree trunk up to a distance of one metre radius and inorganic mulches viz., black polythene and transparent mulch of 100 μ . The analysis on the effect of mulching on yield revealed that mulching with black polythene (M_8) resulted in maximum yield in both the experimental years i.e., 31.18 and 32.12 kg/tree respectively and the subsequent highest yield was obtained from the transparent polythene mulch (M_7) with 30.80 and 31.40 kg/tree and the lowest was recorded under control (M_0) with 25.10 and 25.85 kg/tree in both the years respectively. The yield attributes showed that the maximum fruit size was recorded in black polythene mulch (M_8) measuring 48.60 and 49.04 cm² both the years of observation, the minimum fruit size was recorded under no mulch condition (M_0) with a mean value of 40.08 cm². The data pertaining to the weight of fruit indicated that the weight was highest under black polythene mulch (M_8) with 125.57 and 128.57 g during 2016 and 2017 respectively, subsequently followed by transparent polythene (M_7). The treatment devoid of mulched materials (M_0) recorded the lowest fruit weight mean value of 109.26 g. The quality attributes analysis recorded differences amongst the various treatments tested with TSS values ranging 10.89- 11.53 °Brix, acidity ranging 0.24- 0.44 % and reducing sugar ranging 6.73- 8.21%, amongst which black polythene (M_8) mulch gave the best result and the minimum quality parameters were recorded under control (M_0). Firmness of harvested fruits borne under different mulched treatments recorded the firmest (2.13) under rice husk mulch (M_1) followed by no mulch (M_0), in both the years of investigation.

Introduction

Khasi mandarin is one of the premiere citrus cultivar that has gained a commercial stature

in North-East India. It has a good shelf life and is labelled as the "King of Oranges". Khasi Mandarin alone occupies nearly 41.52 % of the total area and 40.51 % of the total

citrus fruits produced under citrus cultivation in India (Horticulture statistics at a glance, 2018). The quality production of citrus fruits is highly dependent on the soil moisture availability. The presence of adequate moisture in the soil is vital for growth and physiological processes. Citrus (*Citrus* spp.) tree is an evergreen tree and consequently the sap circulation never entirely ceases and transpiration take place throughout the year and thus require good amount of water compared to the other subtropical fruits. In North-East the months of November to March, however, are deprived of rainfall thus producing a dry period. Due to lack of knowledge and economic resources for proper water conservation approaches and no established irrigation means in these regions, the conservation of soil moisture in the root zone of the tree canopy by application of mulches becomes an economic alternative technique. Mulching is an agricultural technology in which the soil is roofed with organic and inorganic materials. Mulching plays an important role in conservation of soil moisture during dry periods, as well as improves physical, biological and chemical properties of soil. The systematic study on the effect of mulching on soil moisture conservation and performance of citrus under Nagaland condition has not been carried out. The crop is mainly dependent on rainfed cultivation in the region and therefore keeping in view and taking all these into consideration the present investigation was carried out to find ways and means to increase the yield and reduce the cost of production so that there is enough fruit production to meet the requirement of the consumers.

Materials and Methods

The mulching experiment was carried out on 15-years old Khasi Mandarin trees which were selected and treated with different mulches for fruit collection at Chuchuyimlang

Village under Mokokchung district of Nagaland. The experiment consisted of nine (9) treatments in Completely Randomized Design (CRD) with three replications. The treatments were M₀- No mulch, M₁- Rice husk, M₂- Saw dust, M₃- Chopped banana leaves & pseudo stem, M₄- FYM, M₅- Forest leaves, M₆-Rice straw, M₇-Transparent polythene (100μ), M₈-Black polythene (100μ). For organic treatments, 5cm layer of rice husk, saw dust, chopped banana leaves and pseudo-stem, FYM, forest leaves & rice straw were applied above the soil surface around the tree trunk up to a distance of one metre radius, respectively. The Recommended dose of fertilizer (RDF) for the investigation was 900g N, 700g P₂O₅, 600g K₂O per plant. The citrus trees were maintained pest and disease free throughout the experiment. Standard procedures were followed for the estimation of yield attributing and fruit quality parameters. The yield was calculated as the product of average fruit weight and the number of fruits per plant. The average length of the fruit was measured from the distal end to the apical tip of the fruit and the breadth was measured at the wider portion of the fruit with the help of Vernier Caliper and the result was expressed in centimetre (cm). The weight of the fruit was measured with the help of electronic weighing balance and results expressed in grams (g).

Different quality analysis method was done after juice extraction. The Total soluble solids (TSS) content of the juice was determined with the help of ERMA Hand Refractometer, calibrated at 20°C temperature, and the results were represented as °Brix. The standard method (AOAC, 2002) was followed to determine the titratable acidity of fruit juice and reducing sugar of fruits was estimated by titrating the juice against Fehling A and Fehling B reagents using Methylene blue as an indicator following the method of Lane

and Enyon (Ranganna, 2008). Parameter of firmness of the fruits was estimated using a five level Hedonic Scale developed by Amarine *et al.*, (1965). The data of the different observations were analysed statistically following the methods described by Gomez and Gomez (1984). Fisher Snedecor 'F' test was used to determine the significance and non-significance of the variance due to different treatments at 5% level of significance.

Results and Discussion

Effect of mulching on fruit yield/ tree (kg)

The experimental results relating to fruit yield per tree revealed that the plants treated with various mulching materials resulted in better fruit yield compared to control. Mulching with black polythene (M₈) resulted in maximum yield in both the experimental years with 31.18 and 32.12 kg respectively with mean of 31.65 kg/plant and the subsequent highest was obtained from the transparent polythene mulch (M₇) with 30.80 and 31.40 kg during the study period. Among the treatments studied, the lowest fruit yield per tree was recorded under control (M₀) with 25.10 and 25.85 kg/plant in both the years respectively. These finding of higher yield under polythene mulch may be attributed to higher number of flowers and increased fruit set due to increased available water in the root zone of the crop, with less evaporation losses and better weed control. It may also be attributed to comparatively increased soil temperature, proper moisture availability (as influenced by mulches), elevated CO₂ level and respiration rate, proper root growth, better uptake of nutrients, and absence of weeds in the field which were responsible for creating favourable microclimate around plants, resulting in efficient utilization of photosynthates for better growth, photosynthate substrates mobilization and

development of the plants. Polythene mulch is known to cause chimney effect which results in abundant CO₂ availability for plants which is necessary for photosynthesis leading to added higher plant growth since plastic mulch is nearly impervious to CO₂. Polythene mulch is also responsible for reduced fertilizer leaching, higher uptake of nutrients, increased water use efficiency, which improved the plant performance and ultimately vegetative growth. The results are in line with the findings of Mal *et al.*, (2006) who reported that more number of flowers recorded in plants under black polythene mulch in pomegranate cv. Ganesh. Bakshi *et al.*, (2014) also reported highest number of fruits per plant in black polythene mulch in strawberry cv. Chandler. The present findings are also in agreement with the verdicts of Kher *et al.*, (2010) in strawberry cv. Chandler, Gosh and Bauri (2003) in Mango cv. Himsagar, Shirgure *et al.*, (2003) in Nagpur mandarin, Patra *et al.*, (2004) in Guava cv. Sardar and Castaneda *et al.*, (2009) on strawberry, Sharma and Kathiravan (2009) in Plum cv. Santa Rosa. In contrast, this result differed from the study Kumar *et al.*, (2012) while studying the impact of different mulching materials on growth, yield and quality of strawberry reported significantly higher fruit yield under transparent polyethylene mulch followed by black polyethylene mulch while it was minimum in control.

Effect of mulching on fruit size (cm²)

The results obtained on fruit size as depicted in the table 1 revealed that there was significant difference among the treatments. The maximum fruit size was recorded in black polythene mulch (M₈) measuring 48.60 and 49.04 cm² followed by the treatment with transparent polythene (M₇) that recorded 46.82 and 47.12 cm² in both the years of observation with a mean value of 48.82 and 46.97 cm² respectively. The minimum fruit

size was recorded under no mulch (M_0) condition with 39.89 and 40.27 cm² during 2016 and 2017 respectively with a mean value of 40.08 cm². The various mulches created a micro-climate condition catering to consistent available soil moisture in the plant basin due to which the roots remained probably active throughout the irrigation season thus leading to optimum nutrient availability, uptake and proper translocation of food materials which accelerated the fruit growth and development.

The results are in agreement with Bakshi *et al.*, (2014) who recorded maximum fruit length of 3.93 cm and fruit breadth of 3.16 cm in strawberry cv. Chandler under black polythene mulch whereas minimum fruit length of 3.00 cm and fruit breadth of 2.00 cm was observed in control. The results are constant with those of previous reports in which plastic mulch treatment recorded maximum fruit size whereas minimum was observed in control (Ghosh and Bera, 2015; Bal and Singh, 2011; Castaneda *et al.*, 2009; Sharma and Khokhar, 2006; Agrawal *et al.*, 2005).

Effect of mulching on fruit weight (g)

The data pertaining to the weight of fruit is represented in the table 1, which indicated that the fruit weight was highest under black polythene mulch (M_8) with 125.57 and 128.57 g during 2016 and 2017 respectively with mean value of 127.07g, subsequently transparent polythene (M_7) treatment followed with 124.87 and 126.60g during the experimental years respectively. The treatment devoid of mulched materials (M_0) recorded the lowest fruit weight mean value of 109.26 g. This might be due to incorporation of mulches that enhanced the nutrient and moisture availability, thereby, helped in improving the soil conditions for better plant growth, balanced C: N ratio and thus increased the production of

photosynthates and ultimately enhanced the fruit characters. It maximized fruit weight by proper movement of active food synthates to sink (Singh *et al.*, 2009). Hasan *et al.*, (2005), Moreno and Moreno (2008) observed significantly increased average fruit weight of tomato with plastic mulch and Jenni *et al.*, (2003) observed in lettuce. This may be attributed to larger size of fruits produced by the plants provided with black polythene mulch, due to increased fruit weight and also creation of favourable soil temperature for fruit development. The present results are in line with the findings of Bakshi *et al.*, (2014) in strawberry cv. Chandler, Bal and Singh (2011) in Ber, Singh *et al.*, (2010) in Aonla, Maji and Das (2008) in Guava, Ali and Gaur (2007) in strawberry, Mukherjee *et al.*, (2004) in Ber, Shirgure *et al.*, 2003 in Nagpur mandarin, Gosh and Bauri (2003) in Mango and Singh *et al.*, 2002 in apricot. The improved rind thickness of fruit resulted by mulching treatments may be due to improved internal physiology of developing fruit in terms of better supply of water, nutrients and other compounds vital for their proper growth and development in peach (Yadav *et al.*, 2013).

Effect of mulching on Total Soluble Solids (°Brix)

Treatment difference in terms of TSS content was noticed within an average range of 10.99 to 11.53 °Brix during the experimental years. The data is presented in Table 2. Black polythene mulch (M_8) treatment recorded maximum TSS with 11.12 and 11.94 °Brix during 2016 and 2017 respectively, then the forest leaves (M_5) mulch with values of 10.98 and 11.83 °Brix in both years of study respectively.

The lowest mean TSS content (10.89 °Brix) was recorded in the treatment no mulch (M_0). Increase in TSS is due to, increased soil

temperature (25.37° C) and maximum nutrient uptake (198.01 kg/ha of Nitrogen and 218.67 kg/ha of Potash) under black polythene mulch treatment.

Mulching ensured higher values of soil moisture as a result of reducing water evaporation from the soil surface. The changes occurred in the soil water regime had an obvious effect on fruit quality. Thus, soil maintenance systems by mulching might have a positive influence on the TSS. Bal and Singh (2011) while studying the effect of mulching material in Ber observed that maximum TSS of 12.16 % was recorded with black polyethylene in combination with gramaxone (1 litre/ha).

They also reported that TSS under paddy straw and sarkanda was higher as compared to control. Similar findings were obtained Kim *et al.*, (2008) studied the effect of pre-harvest reflective mulch on growth and fruit quality of plum (*Prunus domestica L.*) and observed that TSS was higher by 0.3 °Brix in the mulching treatment applied 2 and 3 weeks before harvesting compared to control.

The present observations are consistent with the earlier finding in which black polythene mulch gave better results *viz.*, Bakshi *et al.*, (2014) in Strawberry, Kaur and Kaundal (2009) in Plum, Sharma and Khokhar (2006) in strawberry (*Fragaria x ananassa Duch.*) cv. Chandler, Pande *et al.*, (2005) in apple cv. Red Delicious, Gaikwad *et al.*, (2002) in Nagpur mandarin, and Gosh and Bauri (2003) in Mango.

In contrast, Ghosh *et al.*, (2009) reported in sweet orange [*Citrus sinensis (L.) Osbeck*] cv. Mosambi that juice recovery (59.67 %), TSS (9.90° Brix), TSS: acid ratio (46.33), total sugars (6.05 %), reducing sugars (3.35 %) were highest in plants treated with dry leaves mulch + basin irrigation at 30 l/plant at 20

days interval. Whereas, acidity (0.28 %), Vitamin-C (78.40 mg/100 ml) was highest in black polythene + basin irrigation at 30 l/Plant at 20 days interval. Manoj *et al.*, (2015) reported maximum TSS in Kinnow under paddy straw mulch. Singh *et al.*, (2010) reported that paddy straw mulch in Aonla cv. NA-7 recorded the maximum TSS of 8.25% followed by 8.15% in grass mulch and 8.10% in maize straw mulch as compared to 7.85% in control. Kumar *et al.*, (2012) recorded significantly higher TSS in strawberry under transparent polyethylene mulch followed by black polyethylene. They also reported higher TSS under organic mulches.

Effect of mulching on titratable acidity

In the present investigation, the result obtained on titratable acidity percentage revealed varying degree of response in all the mulch tested. The effective treatment for highest average acidity content (0.88 %) was reported from black polythene mulch (M₈) in both years of study, while the treatment deprived of any mulch materials (M₀) recorded lowest acidity content of 0.86 and 0.88 % during 2016 and 2017 respectively.

Similar results were found by Melgarejo *et al.*, (2012) who reported that organic acids content were slightly higher in plums from trees treated with plastic mulching film. Hassan *et al.*, (2000) studied the effect of different mulches on the yield and quality of strawberry cv. Oso Grande and observed minimum acid content in the fruits harvested from plants under black polythene mulch (1.13 %) and maximum in control (1.33 %). Pande *et al.*, (2005) found higher titratable acidity of 0.25% in apple cv. Red Delicious grown under dry grass mulch followed by 0.20% acid content recorded under black polyethylene and least acid content of 0.19% was recorded under clean cultivation.

Table.1 Effect of different mulching materials on fruit yield per tree, fruit size and fruit weight of Khasi Mandarin

<i>Treatments</i>	<i>Fruit yield per tree (kg)</i>		<i>Fruit size (cm²)</i>		<i>Fruit weight (g)</i>	
	<i>2016</i>	<i>2017</i>	<i>2016</i>	<i>2017</i>	<i>2016</i>	<i>2017</i>
<i>M₀: No mulch</i>	25.10 ^e	25.85 ^d	39.89 ^c	40.27 ^c	108.40 ^c	110.12 ^c
<i>M₁: Rice husk</i>	27.12 ^d	27.50 ^c	42.02 ^{bc}	42.75 ^{bc}	117.87 ^{ab}	120.30 ^{ab}
<i>M₂: Saw dust</i>	28.05 ^{cd}	28.23 ^c	43.35 ^{ab}	43.84 ^{ab}	116.47 ^{ab}	118.60 ^{ab}
<i>M₃: Chopped banana leaves & pseudostem</i>	27.57 ^{cd}	27.98 ^c	45.88 ^{ab}	46.25 ^{ab}	113.70 ^{bc}	116.43 ^{bc}
<i>M₄: FYM</i>	29.67 ^b	29.80 ^b	45.87 ^{ab}	46.46 ^{ab}	120.17 ^{ab}	122.57 ^{ab}
<i>M₅: Forest leaves</i>	29.25 ^b	29.52 ^b	45.65 ^{ab}	45.99 ^{ab}	121.23 ^{ab}	123.70 ^{ab}
<i>M₆: Rice straw</i>	28.17 ^c	29.30 ^b	42.17 ^{bc}	42.48 ^{bc}	118.90 ^{ab}	121.17 ^{ab}
<i>M₇: Transparent polythene (100μ)</i>	30.80 ^a	31.40 ^a	46.82 ^{ab}	47.12 ^{ab}	124.87 ^{ab}	126.60 ^{ab}
<i>M₈: Black polythene (100μ)</i>	31.18 ^a	32.12 ^a	48.60 ^a	49.04 ^a	125.57 ^a	128.57 ^a
<i>SEm±</i>	0.33	0.27	1.71	1.69	3.35	3.45
<i>CD (p=0.05)</i>	0.97	0.80	5.08	5.02	9.94	10.26

Note: Different small letters within the columns after mean values indicate significant differences among treatments at 5% level of significance. Means within columns were separated by Duncan's multiple range test (DMRT).

Table.2 Effect of different mulching materials on total soluble solids, titratable acidity, firmness and reducing sugar of Khasi Mandarin

<i>Treatments</i>	<i>Total soluble solids (°Brix)</i>		<i>Titratable Acidity (%)</i>		<i>Firmness</i>		<i>Reducing sugar (%)</i>	
	<i>2016</i>	<i>2017</i>	<i>2016</i>	<i>2017</i>	<i>2016</i>	<i>2017</i>	<i>2016</i>	<i>2017</i>
<i>M₀: No mulch</i>	10.47 ^c	11.32 ^c	0.23 ^c	0.26 ^c	3.75 ^{ab}	3.67 ^{ab}	6.78 ^c	6.68 ^b
<i>M₁: Rice husk</i>	10.50 ^c	11.47 ^{bc}	0.27 ^{bc}	0.30 ^{bc}	4.17 ^a	4.42 ^a	7.19 ^{bc}	7.39 ^{ab}
<i>M₂: Saw dust</i>	10.56 ^{bc}	11.56 ^{ab}	0.32 ^{bc}	0.33 ^{bc}	3.17 ^{bc}	3.08 ^{bc}	8.03 ^{ab}	8.21 ^a
<i>M₃: Chopped banana leaves & pseudostem</i>	10.65 ^{bc}	11.40 ^c	0.24 ^{bc}	0.27 ^{bc}	2.75 ^{cd}	2.83 ^{bc}	7.48 ^{abc}	7.59 ^a
<i>M₄: FYM</i>	10.66 ^{bc}	11.62 ^{ab}	0.30 ^{bc}	0.33 ^{bc}	2.50 ^{cd}	2.42 ^c	7.75 ^{ab}	7.79 ^a
<i>M₅: Forest leaves</i>	10.98 ^{ab}	11.83 ^{ab}	0.43 ^a	0.44 ^a	2.67 ^{cd}	2.83 ^{bc}	7.80 ^{ab}	8.06 ^a
<i>M₆: Rice straw</i>	10.66 ^b	11.55 ^{ab}	0.28 ^{bc}	0.31 ^{bc}	2.17 ^d	2.08 ^c	7.39 ^{bc}	7.30 ^{ab}
<i>M₇: Transparent polythene (100µ)</i>	10.85 ^{ab}	11.72 ^{ab}	0.33 ^b	0.36 ^b	2.50 ^{cd}	2.58 ^{bc}	7.96 ^{ab}	8.18 ^a
<i>M₈: Black polythene (100µ)</i>	11.12 ^a	11.94 ^a	0.43 ^a	0.45 ^a	2.67 ^{cd}	2.75 ^{bc}	8.19 ^a	8.23 ^a
<i>SEm±</i>	0.13	0.13	0.03	0.03	0.25	0.27	0.26	0.28
<i>CD (p=0.05)</i>	0.38	0.38	0.08	0.08	0.75	0.80	0.78	0.83

Note: Different small letters within the columns after mean values indicate significant differences among treatments at 5% level of significance.

Means within columns were separated by Duncan's multiple range test (DMRT).

However, Kumar *et al.*, (2012) recorded significantly higher fruit acidity in strawberry under transparent polyethylene followed by black polyethylene. The minimum fruit acidity was obtained under control. Bakshi *et al.*, (2014) recorded highest acidity of 0.80% under control whereas, least acidity of 0.64% was found under black polythene mulch in strawberry cv. Chandler. Gaikwad *et al.*, (2002) while studying the effect of different mulches on soil moisture, and soil temperature in Nagpur mandarin found non-significant effect of different mulching treatments on acidity. Gosh and Bauri (2003) while studying the impact of various mulches in mango found that fruit acidity was not influenced by various mulching treatments.

Effect of mulching on firmness

The results obtained by Hedonic scale method on the firmness of harvest fruits borne under different mulched treatments have been presented in the table 2. It is apparent from the data that, the fruits harvested from rice husk mulch (M₁) was firmest with an average value of 4.29, 3.71 and 3.13 was recorded in treatments of no mulch content (M₀) and saw dust mulch (M₂) respectively. Fruits harvested from Khasi Mandarin grown under rice straw mulch recorded the softest with mean value of 2.13.

The firmness and maintenance of structure and function of cell wall, leading to enhanced shelf life and also controlled disintegration of mitochondria and endoplasmic reticulum might be due to effect of mulching since it results in many of the chemical and physical effects that occur during ripening of fruits which are attributed to enzyme action. Softening of fruits during storage is closely associated with an increase in pectin esterase and polygalacturonate activities as reported by Bakshi *et al.*, (2014) in Strawberry. Similar finding by Lang *et al.*, (2001)

reported that mulching the plants helps in better uptake of calcium by the apple tree which will be reflected in storage potential of the fruit.

Effect of mulching on reducing sugar

In the present investigation, the results obtained on reducing sugar percentage revealed varying degree of response in all the mulch tested. It was clear from the results presented in table 2 that black polythene mulch (M₈) resulted in highest reducing sugar content with values of 8.19 and 8.23 % during 2016 and 2017 respectively. The mulch treatments of saw dust (M₂) and transparent polythene (M₇) closely followed with mean values of 8.12 and 8.07 % respectively. The lowest was recorded in treatments without any mulch materials (M₀) reporting 6.78 and 6.68 % during 2016 and 2017 respectively. The present findings are in line with Patil (2011) who reported highest total sugar (6.21%) under paddy straw mulch, reducing sugar (5.38%) under black polythene mulch and non-reducing sugar (1.22%) under paddy straw mulch and least under control. Ghosh and Bera (2015) and Mahmoud and Sheren (2014) also recorded the higher sugar acid ratio in plants mulched with black polythene in pomegranate. Similar conclusions that black polythene mulch results in higher reducing sugar have been drawn by others (Sharma and Khokhar, 2006; Pande *et al.*, 2005).

Sugars are important in attaining pleasing fruit flavours through a sugar to acid balance, attractive colour and wholesome texture. Higher reducing sugar content under black polythene mulch might be due to high TSS and greater utilization and assimilation of carbohydrates favoured by better hydrothermal regime of soil and higher absorption of nutrients, conservation of soil moisture, regulated temperature and

suppression in weed growth. Moisture in the mulched treatments might have helped in better nutrient uptake which was more influenced by the physical conditions of the soil (temperature and moisture) and availability of nutrients in the soil. Mulching also elevates fruit yield and sugar content, which was influenced by environmental conditions at flowering, fruit set and the early stages of fruit development (Singh *et al.*, 2006) in strawberry.

In contrast, Kumar *et al.*, (2012) recorded significantly higher total sugars in strawberry under transparent polyethylene mulching followed by black polyethylene. Das *et al.*, (2010) while studying the effect of soil covers on guava cv. L-49 reported maximum total sugar (6.53%), reducing sugar (3.80%) and non-reducing sugar (2.72%) under paddy straw mulch as compared to other mulches and control.

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How to cite this article:

Alongba Jamir, Manoj Dutta and Sentirenla Jamir. 2020. Influence of Organic and Inorganic Mulches on Yield and its Attributes of Khasi Mandarin (*Citrus reticulata* Blanco) in Foothill Region of Nagaland. *Int.J.Curr.Microbiol.App.Sci*. 9(10): 1994-2004.
doi: <https://doi.org/10.20546/ijcmas.2020.910.243>