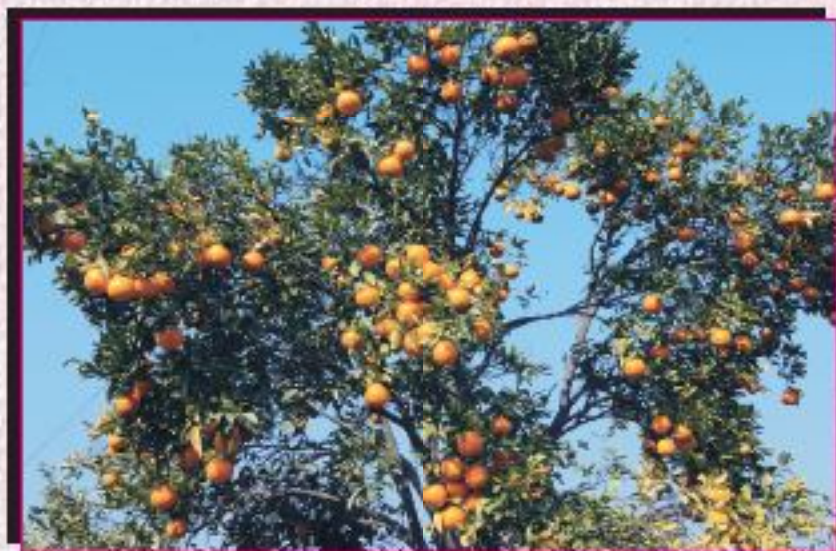




IMPROVING KINNOW MANDARIN PRODUCTIVITY THROUGH MICRO- IRRIGATION AND MULCHING IN DEGRADED RIVERBED LANDS



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FOREWORD



Fruit cultivation is widely practiced with or without intercrops till canopy closer in lower Himalayan region, where a large number of fruit species, viz; mango, litchi, peach, mandarin, sweet orange, lemon, lime, papaya, etc. are commercially grown on field boundaries as well as in block plantation. Approximately one third areas (one lakh hectare) of Doon Valley is affected by soil degradation, which is presently out of cultivation due to presence of high percentage of boulders / stones (70-75%), sands (19-22%), silt (4-5%) and poor clay (2-3%) in the soil. This leads to a very high infiltration rate (30.0 cm hr⁻¹) and poor water holding capacity. On the other hand, is not possible to put arable land under fruit cultivation in view of decreasing land: man ratio on account of industrialization, population pressure, etc. However, degraded river bed lands can be brought under cultivation of fruit species like Kinnow Mandarin with micro-irrigation in addition to soil cover / mulches to reduce evaporation losses. Citrus including Kinnow Mandarin ranks second after mango with respect to production and adoptability of various fruits in Doon Valley of Uttarakhand. The Valley is known as homeland of citrus species on account of climate and hilly terrain. But fruit productivity of citrus is low as compared to national productivity under rainfed conditions as this crop needs assured irrigation at certain stages like fruit setting (March - April), fruit development (May-June) and fruit maturity (November-December). Micro-irrigation is water resource conserving, effective and labour saving practice as it applies water directly to root zone. Plants of Kinnow Mandarin are easy to raise and require less attention of growers for its maintenance and fruits fetch good monetary returns.

Research conducted at CSWCRTI, Dehradun presented in this brochure indicate that productivity of degraded riverbed lands can be improved through cultivation of Kinnow Mandarin with irrigation and mulching with or without intercropping.

(K.S. Dadhwal)

Actg. Director

CSWCRTI, Dehradun

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INTRODUCTION

Doon Valley in the North-Western Himalayan region covers about one lakh hectares of degraded land which is presently out of cultivation due to presence of boulders, gravels, stones, low soil depths and high infiltration rates. Under such conditions, among the prominent fruit species (mandarin, sweet orange, lemon, grapefruit, guava, loquat, mango and litchi) in the region, Kinnow Mandarin is stress tolerant, frost hardy, heavy fruit bearer, easy to establish and can be successfully grown with micro-irrigation and mulch application.

Kinnow Mandarin (*Citrus reticulata*), is an interspecific hybrid which has been emerged as an important fruit crop in the lower Himalayan region. This fruit can be grown well at altitude ranging from 500-1500 msl in the wide range of light and degraded lands with proper drainage. It prefers subtropical climate, with warm summers and moderate winters which is the best suited for growth and development of Kinnow Mandarin. The fruit has high nutritive value, refreshing juice, vitamin C, excellent flavour, attractive appearance and is quite popular in the region. The trees start bearing from third year onwards and continue up to 15-20 years under proper management. These fruits are traditionally raised on gravelly lands under rainfed conditions leading to poor fruit yields and early mortality, making the practice economically unviable. Trees are planted in pits spaced 5-6m apart and this allows an opportunity to utilize the interspaces for growing intercrops in the initial two years. The suitable varieties of mandarin for cultivation in the region on degraded lands are Kinnow, Srinagar, Hill Santara, Khasi Santara, Koorg Santara and Darjeeling Santara.

TECHNOLOGY DEVELOPED

The technology improves productivity of Kinnow Mandarin on degraded lands through scheduling of irrigation (drip) and mulching. Production of sub-tropical fruits on these lands with intercrops during *rabi* season and fallow during *kharif* season till tree canopy closure, is beneficial for productive utilization of these hitherto unproductive lands. Studies for more than fourteen years have indicated that Kinnow Mandarin cultivation can give good dividends and also enrich soil conditions by the turning over of plant biomass.

- Fruit species Kinnow Mandarin block plantation,
- Application of irrigation based on cumulative pan evaporation (80, 120, 160 mm and control) through drip irrigation system and moisture conservation through locally available organic mulch,
- Fallow *Toria* crop rotation initially for two years only.

IMPLEMENTATION OF TECHNOLOGY

Site Selection

- The site for fruit plantation should be cleared (uprooted) of all bushes and unwanted shrubs.
- Select degraded riverbed lands with mild slopes, soil depth between 30-35 cm, consisting of coarse textured soils which is having small to medium sized stones and gravels.
- Two to three ploughings are necessary for better establishment of plantations.
- Demarcate the area for pit digging at 5x5 m in square or triangular system.

Digging and Filling of Pits

- Dig pits of 0.22 cubic meter size by April - May for natural pit solarization for planting during *kharif* season.
- Pits are required to be filled back with a mixture of 75-80% good soil (fertile soils) and 20-25% gravel (<10 mm dia).

Gravel allows sufficient aeration and space for root growth and does not allow water stagnation, since Kinnow Mandarin is sensitive to water logging.

- Kinnow Mandarin plants are treated with Bavistin @ 1.5 g/litre or Diathane Z-78 @ 3 g/litre or chloropyriphos @ 2 ml /litre of water.
- Young Kinnow Mandarin plants at the time of planting require 25 kg FYM and 100:50:25 g NPK in addition to 25 g of each zinc, iron, borax, magnese per pit.
- N, P and K can be supplied through urea (198 g), diammonium phosphate (109 g) and 167 g muriate of potash per plant.
- Planting is to be completed by July-August.
- Kinnow Mandarin plants are to be kept upright by proper planting and propping with 1.5 m long sticks.
- Watering is done immediately after planting with about 20 litre of water.

Irrigation

- Young plants need water at fortnightly (15 days) interval during winter and at weekly (5-6 days) interval during peak summer with application of grass mulch @ 20 kg/plant.
- Fruiting and fruit development stages are critical phases requiring irrigation.
- Install drip irrigation system for applying 20 litre of water per day per plant at the rate of 8 litre per hour. Alternatively, apply 40 litre of water twice in a week during summers or moisture stress period with application of grass mulch @ 20 kg/plant (Photo 1).
- Application of water at 80 mm CPE with grass mulch must be given for higher returns.

Precaution

- A total of 18 irrigations are required for Kinnow Mandarin with a depth of 4 cm.
- Irrigation is not to be done during flowering as the tree sheds flowers if watered.



Photo 1: Kinnow plants with grass mulch

FRUIT YIELD

- Kinnow mandarin trees begin to yield fruits after the fourth year of planting and average yield of 70.3 kg/tree (28.12 t/ha) is expected at 80 mm pan evaporation with 632 cm/ha water and locally available grass mulch.
- Commercial bearing begins from the 7th year and yield up to 85 kg/tree is obtained (Photo 2).



Photo 2: Kinnow Mandarin branch with heavy fruiting

- Decline in the yield begins from the 15th year and by the 20th year of planting, orchard needs to be replaced with a fresh plantation.

MAINTENANCE AND MANAGEMENT

- Pruning and training are to be carried out in newly established orchard in the month of January to allow four shoots to grow in four directions (open leader system of training).
- Subsequent pruning is essential for fruit bearing plants just after fruit harvesting every year to ensure proper sunlight for sustainable fruiting.
- Water sprouts / off shoots are to be removed periodically. The cut ends of every branch and main shoot is pasted with *Chaubatia* paste or Bordeaux mixture.
- Manures and chemical fertilizers are applied on the basis of the age of fruit plants in two split doses i.e. in February-March and September-October every year.
- One year old Kinnow Mandarin plant requires 25 kg well decomposed farmyard manure, 100 g nitrogen, 50 g phosphorus and 25 g potash in addition to 25 g of zinc, borax, magnese and iron in each pit.
- Doses of manures and fertilizers are increased with the increasing age and are stabilized after seven years of age.
- Kinnow Mandarin fruit trees at 7 years and above age require 700 g nitrogen, 350 g phosphorus and 175 g potash per plant. This can be supplied through urea (1978 g), diammonium phosphate (1087 g) and 1667 g muriate of potash.
- Trees of Kinnow Mandarin are to be painted with mixture of lime (200 g) and chloropyriphos (2.0 g) per liter of water to prevent termite and other fungal attack.

INTERCROPS

The operation calendar is given in Table 1.

Table 1 : Month wise calendar of operations in a new Kinnow Mandarin orchard along with field crops

Activities	Months												
	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
Site selection and clearing	✓	-	-	-	-	-	-	-	-	-	-	-	-
Pitting and filling back	-	✓	✓	-	-	-	-	-	-	-	-	-	-
Planting and watering of fruit plants	-	-	-	✓	✓	-	-	-	-	-	-	-	-
Training & pruning	-	-	-	-	-	-	-	-	-	-	✓	✓	-
Weeding and fertilizer application	-	-	-	-	-	✓	✓	-	-	-	✓	✓	-
Mulching	-	-	-	-	-	-	✓	-	-	-	-	-	✓
Plants propping	-	-	-	-	✓	✓	✓	✓	-	-	-	-	-
Fruit harvesting	-	-	✓	✓	-	-	-	-	-	-	-	-	-
Monitoring	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Field cleaning	-	-	-	✓	-	✓	-	-	-	-	✓	-	-
Ploughing for sowing of Toria	-	-	-	-	-	-	✓	-	-	-	-	-	-
Toria harvesting	-	-	-	-	-	-	-	-	✓	✓	-	-	-

Kharif

- Field is kept fallow during *kharif* season for fertility buildup. The inter space between the plants is ploughed upto the plough sole depth (15-20 cm) during rainy season for recycling of ground cover biomass.

Rabi

- Field is prepared in the first week of October by ploughing up to the plough sole depth.
- *Toria* is broadcast @ 4.0 kg/ha just after the second ploughing on the same day or the next day, *Toria* can be cultivated for initial three years (Photo 3).
- Crop is harvested in the month of January and stover is ploughed back into the soil for soil enrichment.
- An average yield of 4.87 q/ha is obtained from the degraded lands.

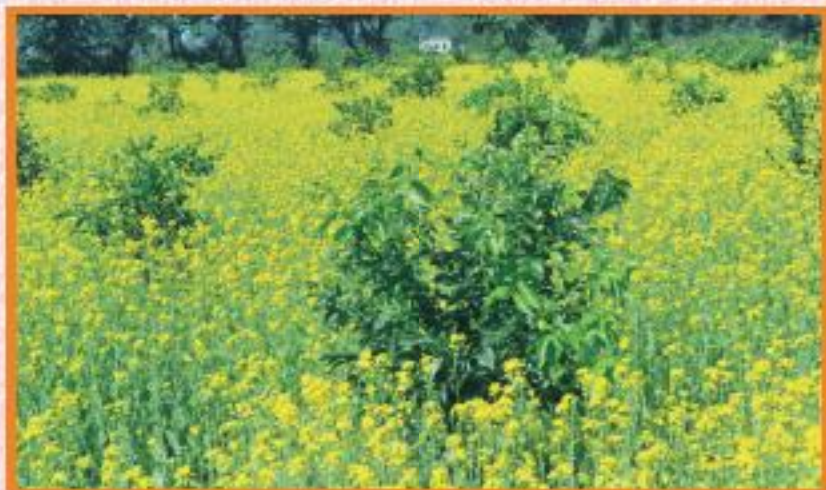


Photo 3 : Three years old Kinnow Mandarin with *toria* on degraded lands

DISEASES AND THEIR CONTROL

- 1) Leaf fall and fruit rot:** Shedding of leaves and fruits during monsoon starts when humidity is high in the atmosphere. In severe cases the entire foliage and fruits dry up. Two sprays of Bordeaux mixture @ 1% during May-June and August-September are effective in controlling the disease.
- 2) Fruit drop:** Fruit drop is common in Kinnow Mandarin grown on degraded lands which is directly correlated with moisture present in the soil. This can be controlled by spraying of 2, 4-D @ 20 ppm at button stage or planofix @ 20 ppm during March-April and August-September.
- 3) Gummosis or trunk rot:** Rotting of the tissues inside the branches and exudation of gum from the bark of stem occurs. To control the disease, do the following :
 - (i) Scrape affected portion along with extra healthy tissue and apply 1% Bordeaux paste
 - (ii) Avoid stagnation of water around trunk as a preventive measure.
- 4) Citrus root rot:** In this case, feeder and secondary roots are damaged due to rotting. In severe cases even the trunk at the surface level turns black. For control of the disease, these measures are advocated :

- (i) Remove the soil around the tree trunk and treat affected parts with 1% potassium permagnate solution followed by application of 1% Bordeaux paste.
 - (ii) Avoid water stagnation at the tree base, provide proper drainage in the orchard and prevent root injury.
- 5) **Powdery mildew:** Appearance of powdery growth (ash colour) on the new flushes, flowers and fruit buds starts when the atmosphere is humid and cloudy. Spray wettable sulphur @ 0.2% (2 g sulfex/litre) or Karathane @ 0.1% (1 ml/litre) to minimize the incidence.
- 6) **Pink disease:** Growth of pinkish fungus on the barks of the affected branches is the main symptom. This can be managed in two ways :
- (i) Pruning of affected branches followed by burning.
 - (ii) Spray 1% Bordeaux mixture.
- 7) **Viruses:** Gradual loss of the plant vigour yellowing of leaves, leaf shedding and low production. In some cases sudden wilting of the plant, leaf shedding and drying of the plant take place. Tristeza and Greening are the important viral diseases which are transmitted through insect vectors namely aphid and psylla. The diseases can be managed by
- (i) Use of virus resistant rootstocks / virus free bud wood material, and
 - (ii) Follow control measure of aphid and psylla given in insect control part.

Important Insects and Their Control

- 1) **Lemon butterfly (Orange dog):** Caterpillars of lemon butterfly starts feeding on new leaves and even on fruit (Photo 4). This can be controlled by hand picking of caterpillars and killing by using kerosene or by spraying of monocrotophos @ 1.0 ml/litre of water and wood material.
- 2) **Orange shoot borer:** Grubs enter inside stem by boring the tender pith and the tissues. It is evidenced by bore hole on the stem and saw dust around tree trunk. Effective measures to control the borer are
- (i) Pruning and burning of the affected shoots.
 - (ii) Spray of monocrotophos @ 1 ml/litre of water.



Photo 4 : Caterpillar of lemon butterfly feeding on Kinnow leaf

- 3) **Aphid and Psylla:** Aphids are dark brown plant lice live in colonies on new shoots. Psylla is small greenish insects. Aphid and psylla are sucking insects and attack tender shoots, flowers and fruits resulting in gradual tree drying. These are effectively controlled by spray of Metasystox @ 1.0 ml per litre of water or dimethoate @ 1.5 ml per litre of water.
- 4) **Leaf miners:** Their presence is detected by appearance of zigzag silvery-white galleries on both surfaces of tender leaves eventually curling and twisting of leaves take place. The infestation of insect can be controlled by using Rogor or Metasystox @ 1.0 ml/litre of water.

Nutritional Disorders

Micro-nutritional disorders : Deficiency of iron, copper and zinc are commonly observed in kinnow mandarin on degraded lands.

- a) **Iron deficiency:** This is diagnosed by interveinal yellowing of leaves and eventual dieback of shoots (Photo 5). Deficiency can be corrected by spraying FeSO_4 @ (0.5%) or basal application of FeSO_4 @ (200-300 g/tree/yr).
- b) **Copper deficiency:** Copper deficiency results in dark green leaves, dieback of twigs, oozing of gum on stems



Photo 5 : Iron deficiency symptom of Kinnow Mandarin

(exanthema) and on fruits. Deficiency of this nutrient can be overcome by spraying of 0.1% copper sulphate.

- c) **Zinc deficiency:** Little leaf, rosetting, interveinal chlorosis, whitening of leaves are common symptoms (Photo 6). Zinc deficiency can be corrected by spraying $ZnSO_4$ @ (0.5%) or basal application of $ZnSO_4$ @ (200-300 g/tree/yr).



Photo 6 : Zinc deficiency symptom of Kinnow Mandarin

BENEFIT

Kinnow Mandarin can be cultivated on degraded lands in the Doon Valley with drip irrigation and organic mulching along with intercropping initial three years. Hence, is a useful intervention for improving productivity of such lands. Besides providing nutritional security in the form of fruits (santara) and oil from toria, it also improves soil physico-chemical properties by turning over biomass (litter fall) @ 2.0 t/ha.

ECONOMICS

An orchard of Kinnow Mandarin can be established by investing ₹ 54,450 /ha on degraded lands (Table 2). However, this cost can be further reduced to ₹ 46,050 /ha by *in-situ* budding techniques where grower can save ₹ 8,400 /ha (Table 3), Kinnow plant starts fruiting by the fourth years of planting. An average yield of 70.3 kg/tree (28.12 t/ha) is harvested with irrigation of 6.32 lakh litres/ha and mulching. Maximum B: C ratio of 5.10 was calculated for a period of 20 years life of trees with 7 years payback period. The net returns/ha ranged between ₹ 39,831 to

Table 2: Cost of establishment of Kinnow Mandarin at 5 x 5 m spacing (2010 prices)

Activity / Work	Approximate cost (₹/ha)	
	<i>ex-situ</i> budding	<i>in-situ</i> budding
400 No. @ ₹ 16,50 / budded plants (<i>ex-situ</i>) and ₹ 5 / <i>in-situ</i> budded plants	6,600	2,200
Cost of pit digging and refilling @ ₹ 30/pit	12,000	12,000
400 cft FYM @ ₹ 6/cft	2,400	2,400
Pit filling mixture with pesticide @ ₹ 10/pit	4,000	1,000
Planting, staking and watering @ ₹ 5.0/unit	2,000	2,000
Pesticide application @ ₹ 5,0 / unit	2,000	2,000
Weeding, hoeing, fertilizer application twice in a year @ ₹ 10/unit	4,000	4,000
Installation of drip system and fuel charges	16,000	16,000
Mulch application @ ₹ 10 /unit	4,000	4,000
Miscellaneous (implements, tilling, etc)	1,450	450
Total	54,450	46,050

Table 3: Average fruit yield and net returns of Kinnow Mandarin on degraded lands (average 12 years)

Irrigation at different CPE +mulch	Water applied (LL/ha)	Fruit yield (kg/tree)	Fruit yield (t/ha)	Total Income (₹/ha)	Total expenditure (₹/ha)	Net returns (₹/ha)
80 mm	6.32	70.30	28.12	1,40,600	60,435	80,165
120 mm	4.80	58.41	23.36	1,16,820	52,450	64,370
160 mm	3.40	46.27	18.51	83,286	43,455	39,831
Control	-	40.18	16.07	64,288	34,450	29,838

CPE = Cumulative Pan Evaporation, LL = Lakh litre

₹ 80,165 under different irrigation frequencies and mulching. These net returns are higher than the return (29,838) of rainfed condition (control). An average yield of toria (4.87 q/ha) as an intercrop is also obtained from degraded lands with Kinnow Mandarin production system in the initial three years prior to canopy closure.

SCOPE OF APPLICATION

This land use practice is suitable for the lower western Himalayan region up to an elevation of 1500 m amsl, where the fruit alone or in combination with intercrops can be grown together on degraded lands/ lands not suitable for cultivation of field crops in the 11 hilly states of north-western and north-eastern Himalayan region of India.



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