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The Orange:
A Trial of Stocks at Peshawar

BY

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PREFACE

TO ensure in the scions certain desirable qualities, such as long life and hardiness in the tree or the dwarf habit with early and abundant bearing, or superior quality in the fruit, stocks of various kinds are employed.

The influence of the stock on the scion has not yet been fully tested in India for any fruit.

In this Bulletin it is proposed to show, as a result of experiments in the North-West Frontier Province, that success in the cultivation of the orange in North-West India mainly depends on the character of the stock used.

W. R. B.

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The Orange:
A Trial of Stocks at Peshawar.

(Received for publication on 23rd August, 1919.)

I. Introduction.

In India, an orange tree, which is properly treated, may be depended on to bear a paying crop at the age of six years, and to yield 300 fruits a year for a period of 15 to 20 years after coming to maturity. After visiting many nurseries and gardens throughout India, the writer estimates that nurserymen sell 400,000 orange plants a year they have probably distributed 8,000,000 plants at the good sum of Rs. 20,00,000 in the past 20 years. If the trees had been set out at 18 feet apart, on simple calculation, India's groves should now comprise no less than 5,000,000 bearing trees on 60,000 acres. And as the average price of oranges is not less than Rs. 2 per hundred, it might be expected that India's orange crop would be worth Rs. 3,00,00,000 a year.

Unfortunately this is very far from the actual state of affairs. A considerable proportion of the budded trees have declined and died without bearing any crop at all : very few of the trees have yielded 300 oranges even for a year or two : not many of the trees have flourished for 20 years. The area occupied by groves is far short of 60,000 acres : the crop is worth but a small part of the grand sum of Rs. 3,00,00,000.

Nevertheless, some vigorous, bountiful trees that have borne an average crop of 300 fruits for many years and, more rarely, profitable highly fruitful groves are occasionally to be seen in various parts of India. These indicate that the orange can be grown very well in the country. Why then are India's groves so unfruitful compared with similar groves in Europe, America or Australia ? What has caused the death of so many of the trees that have been planted ?

In India oranges are set out with care on good land and, generally, the groves are protected from drought. The orange is one of the easiest fruit trees to grow—requiring far less pruning, thinning or spraying than peaches and plums—and as a matter of fact the Malta and the Sangtara orange trees receive more care than several other kinds of fruit trees which reach greater perfection from an Indian gardener's hand. Unsuitable soil, unfavourable climatic conditions cannot be the

factors that cause the comparative failure of the orange in India. The orange flourishes on a great variety of soils over the sub-tropical world, and India has plenty of good fruit land and a considerable range of climate. There must be other circumstances which cause the orange groves of India to fail.

Investigations carried out in many gardens and nurseries throughout India, in the years 1905-11, inclined the writer to believe that this failure has been caused by mistakes in the preparation of the plants in the nurseries. In those parts of India that were visited, it was found that nurserymen employed several kinds of stocks for the Malta and the Sangtara, and as the nurserymen were not fruit-growers, they had no assured knowledge of the effects of the stocks they used on the development of trees in the groves. Indeed, the opinions of nurserymen on the merits of stocks were everywhere contradictory and often palpably unreliable: each appeared to use the stock he could most cheaply and conveniently obtain, or which quickly raised nursery plants fit to sell.

In some other matters the failure of the trees was undoubtedly caused by unfavourable conditions that prevailed in the nurseries. The young plants were overcrowded; they struggled for existence with old nursery plants and frequently with tough root-weeds. The areas were so small and congested that suitable rotations could not be followed. In the preparation of the plants careless work was also observed. The orange buds were inserted too high in the stocks. Very often old stocks were used on which buds had failed in several previous years.

In short, the nursery plants were found to be badly grown and unreliable. They were altogether inferior to the plants which nurserymen sell in Europe, America or Australia. No fruit-grower in those countries would set out the poor trees which Indian nurserymen customarily distribute.

These are some circumstances that appeared to the writer to account for the failure of orange groves in India. But despite them all, it yet seemed that the proportion of trees which reach mature age and fruitfulness should be far better than it was found to be.

Outstanding clear above all other probable causes of failure were the facts that several distinct kinds of stocks were used: that great difference of opinion existed amongst growers regarding the merits of the various stocks: that all the stocks could hardly be equally suitable to both the Sangtara and the Malta, and that some of the stocks employed might be unsuitable to either the Malta or the Sangtara.

Accordingly, when orchards at the Peshawar Agricultural Station were being laid out in 1911, the opportunity was taken to include a test of the orange stocks which are commonly used for the Malta and the Sangtara in North-West India.

Budded plants were obtained from a reliable Indian source, good clean cultivation was practised, and irrigation was used with caution. No calamity befell the trees during the trial.

The results shown with the Malta and the Sangtara will be dealt with separately.

II. Climate of the Peshawar Valley.

The climate of the Peshawar valley is described in the District Gazetteer as follows:—

Four seasons are recognized at Peshawar: Spring in February, March and April. During the earlier part of this period there are occasional light hail-storms and frequent thunderstorms, and usually rain falls to the extent of three or four inches. Normals of temperature derived from the data of 33 years are as follows:—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
February	65·7	42·5	54·1
March	75·0	51·7	63·3
April	85·5	60·3	72·9

Summer in May, June and July. Rain rarely falls during this season though thunderstorms sometimes continue well into May which is the hottest of the year. It is frequently hazy, and dust-storms occur in June and July. Normals of temperature are as follows:—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
May	98·1	69·9	84·0
June	105·9	77·3	91·6
July	102·7	79·2	90·9

Autumn in August, September and October. The season is ushered in by the hot weather rains which do not, however, always reach the valley. October is usually dry. They break over the district in four or five violent storms at intervals of a few days, and two or three inches of rain fall on each occasion. During the first part of this season the sky is more or less uniformly overcast with clouds and the air is steamy and oppressive. Normals of temperature are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
August	99·2	78·0	88·6
September	95·6	70·5	83·1
October	88·2	57·9	73·1

Winter in November, December and January. During this season the weather is variable. The sky is at first hazy, then cloudy, with sometimes slight rain towards the end of December. There is a remarkable absence of wind generally and the air is still and stagnant. The first touch of frost is expected towards the end of November. Normals of temperature are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
November	77·3	46·1	61·7
December	69·0	39·2	53·1
January	63·0	39·6	51·3

The average annual rainfall in the Peshawar valley is 14 inches only. But the experimental groves were irrigated, and never suffered from a deficiency of soil moisture.

III. The Stocks Used.

The trial comprised the following :—

Fifty plants on *Citrus Limonum*, Osbeck, var. This is the "rough lemon" of California and Florida, the "khatti" of the Punjab and North-West Frontier Province, the "kharna" of the United Provinces.

Fifty plants on *Citrus Aurantium*, Linn. This is the "sour" orange of California and Florida, the "khatta" of North-West India, the "narang" of the North-West Frontier Province. It is sometimes called the Seville or marmalade orange.

Fifty plants on *Citrus Limonum*, var. "sweet lime" or "sharbete" or "mitha". The writer has not seen any accurate botanical description of the "sweet lime". The fruit is insipid-sweet and is liked by Indians. But it does not appear to be cultivated in Europe, America or Australia.

Fifty plants on *Citrus Medica*, Linn. This is a large coarse citron which is called the "galgal" in North-West India.

IV. The Malta (*Citrus Chinensis*) Grove.

Soil. The following is a report by the Imperial Agricultural Chemist at Pusa on two samples of soils from the Malta grove :—

	0"-1'	1"-3'
Laboratory No.	33-1919	34-1919
	%	%
Moisture (hygroscopic)	0·93	1·02
Combined moisture and organic matter and undetermined	1·38	1·28
Sand and insoluble matters	65·26	64·29
Iron (Fe_2O_3)	4·92	4·78
Alumina (Al_2O_3)	9·61	9·45
Oxide of manganese (Mn_3O_4)	0·02	0·09
Lime (CaO)	9·04	9·92
Magnesia (MgO)	0·68	0·74
Potash (K_2O)	0·94	0·89
Soda (Na_2O)	0·37	0·29
Phosphoric acid (P_2O_5)	0·16	0·14
Carbonic acid (CO_2)	7·58	8·10
Sulphuric acid (SO_3)	0·04	0·03
	100·00	100·00
Available potash (K_2O)	0·017	0·007
„ phosphoric acid (P_2O_5)	0·0038	0·0012
Organic nitrogen	0·05	0·03
Humus	0·80	0·60

REMARKS. The soils are very deficient in available P_2O_5.

V. The Sangtara (*Citrus nobilis*, Lour.) Grove.

Soil. The following is a report by the Imperial Agricultural Chemist at Pusa on two samples of soil from the Sangtara grove :—

	0″-1′	1″-3′
Laboratory No.	31-1919	32-1919.
	%	%
Moisture (hygroscopic)	1·92	1·62
Combined moisture and organic matter and undetermined	2·65	2·02
Sand and insoluble matters	61·75	62·37
Iron (Fe_2O_3)	5·53	5·29
Alumina (Al_2O_3)	10·88	10·38
Oxide of manganese (Mn_3O_4)	0·03	0·08
Lime (CaO)	9·36	9·64
Magnesia (MgO)	0·87	0·74
Potash (K_2O)	1·12	1·02
Soda (Na_2O)	0·39	0·32
Phosphoric acid (P_2O_5)	0·16	0·16
Carbonic acid (CO_2)	7·21	7·96
Sulphuric acid (SO_3)	0·05	0·02
	100·00	100·00
Available potash (K_2O)	0·015	0·008
„ phosphoric acid (P_2O_5)	0·0016	0·0009
Organic nitrogen	0·05	0·04
Humus	1·35	1·20

REMARKS. The soils are very deficient in available P_2O_5

FIG. 1.

Left

Maltas budded on *C. Aurantium*, Linn., the "sour orange" of California and Florida, the "batta" of North-West India.

Right

Maltas budded on *C. Limonum*, Osbeck, the "rough lemon" of California and Florida, the "khatti" or "kharna" of North-West India.

Age 2 years 3 months from date of planting.

The Maltas on the rough lemon have made an excellent beginning. The Sangtaras on this stock did not grow very well (Plate VIII, fig. 2).

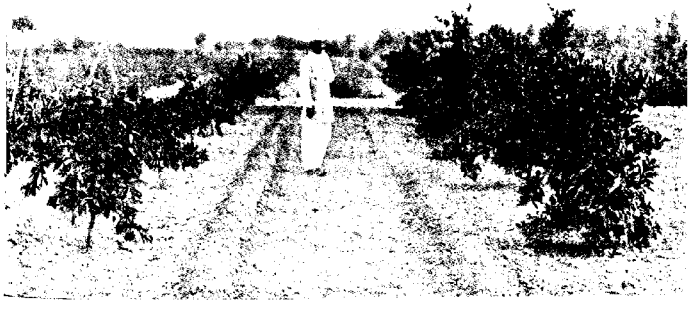


FIG. 2.

Left

Maltas budded on *C. Limonum*, var. "pindee," "mitha" or "sweet lime" North-West India.

Right

Maltas budded on *C. Limonum*, var. "rough lemon" of California and Florida, the "khatti" or "kharna" of North-West India.

Age 2 years 3 months from date of planting.

Here again the "rough lemon" is markedly the better stock.

Fig. 1.

A Malta on *C. Limonum*, var. "rough lemon", "khatti" or "kharna": age 4 years 6 months from date of planting: crop 200 oranges: height 11 ft. 10 in.: breadth at 1 ft. from the ground, 9 ft. 6 in. The "rough lemon" stock certainly appears to give vigour and fruitfulness to the Malta.

Fig. 2.

A Malta on *C. Limonum*, var. "sharbeti," "mitha" or "sweet lime": age 4 years 6 months from date of planting: crop 25 fruits: height 5 ft. 9 in.: breadth at 4 ft. from the ground, 5 ft. 4 in. The Malta does not grow at all well on the "sweet lime".

Yet the "sweet lime" proved the best stock for the Sangtara (*C. nobilis*, Lour.) (Plate IX, fig. 1.)

FIG. 1.

on *C. Aurantium*, Linn., the "sour orange" of Florida, the "khatta" of North-West India: months from date of planting: crop 10 oranges: ...m.; breadth at 4 ft. from the ground, 5 ft.

...ingly small and unthrifty the tree is compared ... of similar age which is on the "rough lemon" ...16.

...ordinary that this "sour stock", which is ... most popular for the Malta or any sweet orange ... so unsuitable for the Malta in North-West ... discussing stocks for the sweet or Malta orange, ... "Standard Cyclopædia of Horticulture" says: ... more commonly used in the world's *citrus* ... the sour orange. Trees propagated on it are ...gorous and produce fruit of high quality. The ... is resistant to mal-di-goma and some other ... which affect other orange stock. Wherever ... should be given preference. It is a congenial ... of important varieties of oranges, the Satsuma (*C.* ... var.) alone excepted." *Contrary to American ... sour orange is not a suitable stock for the sweet ... orange in North-West India. The Sangtara or ... nobilis, Lour.), on the other hand, does well ... orange in North-West India.*

FIG. 2.

A Malta on *C. Medica*, Linn., the citron or coarse "g... North-West India: age 4 years 6 months from date of ... crop 16 oranges: height 3 ft. 6 in.; breadth 3 ft. Alth... used by many nurserymen, the citron gives neither vi... fruitfulness to the Malta. On the other hand the Sar... *nobilis*) grows quite well on the citron. But the... produced thereby are of very poor quality.

Left

Maltas on *C. Limonum*, var. "rough lime" "khatti" or "khurna".

Age 4 years 6 months from date of planting.

Right

Maltas on *C. Limonum*, var. "sharbete" "mitha" or "sweet lime".

Roots of four distinct *Citrus* stocks, aged 6 years, each of which had a Malta scion or head.
Left to right (1) *C. limonum*, var. "sharbete", "mitha" or "sweet lime" of North-West India. (2) *C. Medica*, Linn., the coarse citron or "galgal" of North-West India. (3) *C. Limonum*, var. "rough lemon" of America, "khatti" or "kharna" of North-West India. (4) *C. Aurantium*, Linn., the sour orange of America, the "khatta" of North-West India.
The sour orange and rough lemon stocks were raised from seed in the spring of 1910. The citron and the sweet lime stocks were propagated from cuttings in the same year. The roots that are shown in the plate are typical of many that were examined.
With its great spread of strong well developed roots, the rough lemon could hardly fail to encourage a vigorous, fruitful Malta head. The roots in this picture may be compared with those in Plate XI.
The results of the tests might have been more convincing if all the stocks had been raised from seed. But the sweet lime yields few seeds, which do not germinate well: nor do the young seedlings grow freely. On the other hand, the sweet lime and the citron are easily raised from cuttings and they grow with great vigour and fruit very heavily when they are not budded. It is noteworthy that the Sangtara grows and fruits well on the sweet lime stock which has been propagated from a cutting. (Plate IX, fig. 1; and Plate XI, fig. 1.)

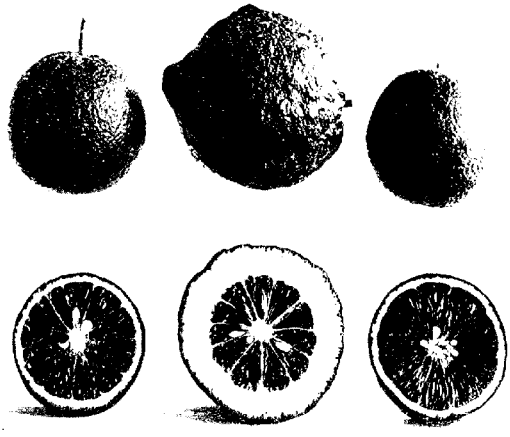


FIG. 1.

In the centre, fruits of *C. Limonum*, the "rough lemon," "khatti" or "kharna"; on the right and left, Malta fruits that were grown on the "rough lemon" stock.

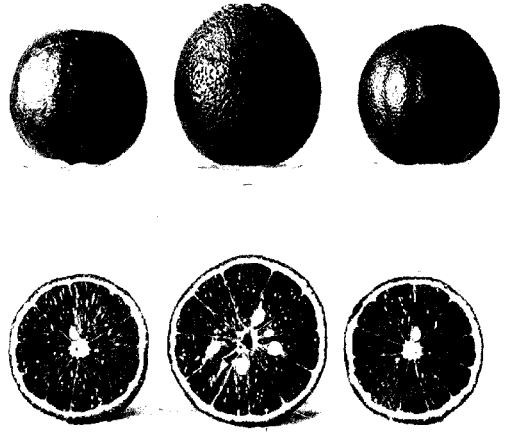


FIG. 2.

On the right and left, *C. Limonum*, var. "sharbeti," "mitha" or "sweet lime"; in the centre, Maltas that were grown on the "sweet lime".
The "sweet lime" has thin, clear, pale lemon-yellow, smooth skin and few seeds. The Malta in the picture has a hollow heart, but this was probably caused by the fruit having been in store for nearly two months

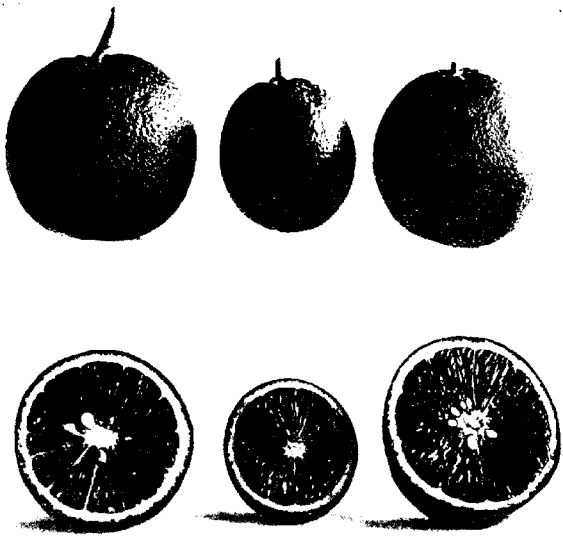


FIG. 1.

On the right and left are Maltas that were grown on *C. Limonum*, var. "rough lemon", "khatti" or "kharna"; in the centre, Maltas that were grown on *C. Limonum*, var. "sharbete," "mitha" or "sweet lime".

On the "sweet lime" stock, Malta fruits from trees which are over six years of age are generally small and, invariably, they contain few seeds.

FIG. 2.

Top row. Malta oranges which were grown on the "sweet lime", "mitha" or "sharbete" (*C. Limonum*). On this stock the fruits are smaller and have much thinner skin than Maltas which are grown on any other stock in North-West India. The oranges are distinctly oval in shape, and pale unattractive lemon-yellow in colour. The seeds average about seven in number. The juice is moderately abundant, sweet, and in flavour better than that of oranges on any of the other stocks which were used in the trial.

Bottom row. Malta oranges that were grown on the "rough lemon", "khatti" or "kharna". On this stock the Maltas are large and rather coarse, perfectly globular, rich attractive orange in colour and inclined to be thick-skinned. The juice is very abundant, sparkling and, on young trees especially, somewhat too acid. The seeds are numerous and large, usually numbering about sixteen or seventeen.

FIG. 1.

Left
Sangtaras budded on "sour orange," Khatta" (*C. Aurantium*, Linn.)

Right
Sangtaras budded on citron, "galgal" (*C. Medica*, Linn.).

Age 2 years 3 months from date of planting.
Unlike the Sangtara, the Malta entirely fails on the citron. (Plate III. fig. 2.)

FIG. 2.

Left
Sangtaras on "sweet lime", "mitha", or "sharbete" (*C. Limonum*).

Right
Sangtaras on "rough lemon", "khatti" or "khatta" (*C. Limonum*).

Age 2 years 3 months from date of planting.
The Malta unlike the Sangtara is more vigorous on the "rough lemon" than on the "sweet lime". (Plate I, fig. 2, and Plate IV.)

FIG. 1.

Sangtara on the "sweet lime", "sharbete," or "mitha" (*Aurantium*, Linn.): age 7 years from date of planting. On the "sweet lime" the Sangtara is tall, and its branches, lacking [illegible] are easily broken by the wind or weight of fruit. [illegible] years of age the crop was 500 good oranges per tree. [illegible] unfortunate that the "sweet lime", which gives [illegible] with abundant fruit of high quality to the Sangtara, [illegible] induces a weak Malta tree with, however, fruit of [illegible] quality. (Plate I, fig. 2; Plate II, fig. 2; and [illegible].)

FIG. 2.

A Sangtara on the "sour lime" or "khatta (*Aurantium*, Linn.): age 7 years from date of planting. picture very well shows the vigorous compact habit the Sangtara assumes when it is budded on the orange". Yet the Sangtara (*C. nobilis*, Lour.) is no factory on the "sour orange" in California and F The Malta, on the other hand, does well on the "sour or in the orange States of America, but fails entirely stock at Peshawar. (Plate III, fig. 1.)

FIG. 1.

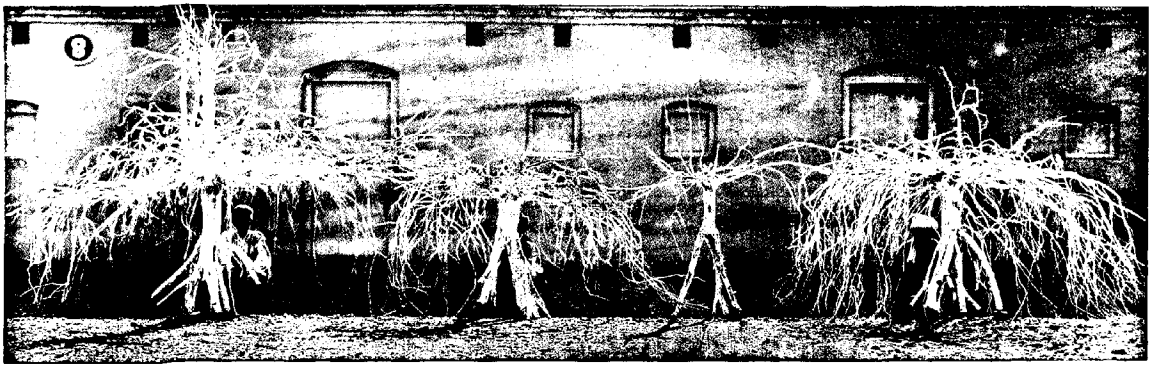
A Sangtara on the "rough lemon", "khatti" or "[illegible]" (*C. Limonum*, Osbeck). At the age of 7 years all [illegible] in the trial were dying or dead. They began to [illegible] after fruiting heavily in their sixth year, when the [illegible] crop per tree was 321 fruits.

It is truly extraordinary that the "rough lemon" which [illegible] great vigour with fruitfulness to the Malta is totally [illegible] for the Sangtara. (Plate I; Plate II, fig. 1.)

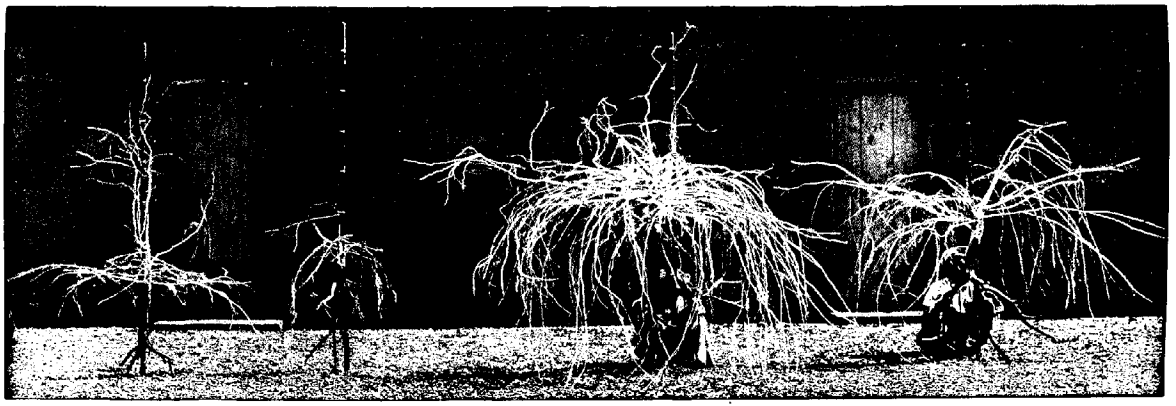
FIG. 2.

A Sangtara budded on the citron or "galg *Medica*, Linn.): age 7 years from date of planting. stock the Sangtaras were vigorous and healthy un attained 6 years of age. Then some of the branche to die. Very few oranges were produced until th year. The average crop per tree was then 440 fru these were dry, flavourless and unsaleable.

It is noteworthy that the Malta hardly grow when it is budded on the citron. (Plate III, fig. 2



Roots aged 7 years which had Sangtara (*C. nobilis*, Lour.) heads.



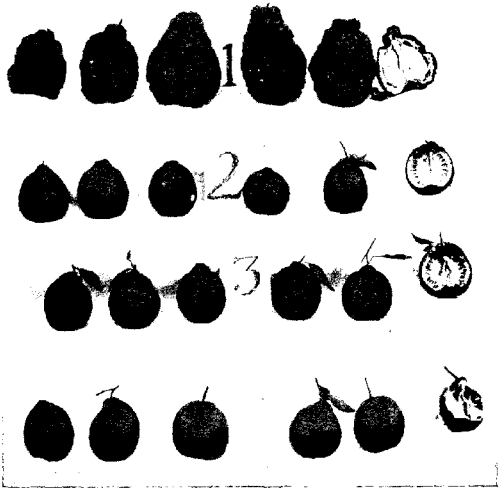
Roots aged 6 years which had Malta (*C. Chinensis*, Osbeck) heads.

2 3

Reading from left to right, (1) "sour orange" or "khatta" (*C. Aurantium*, Linn.), (2) citron or "galgal" (*C. Medica*, Linn.), (3) "rough lemon" "khatti" or "kharna" (*C. Limonum*, Osbeck), (4) "sweet lime" "mitha" or "sharbete" (*C. Limonum*).

It seems incredible that the roots numbered 1, 2, 3 and 4 in the upper and lower pictures are the same stocks, altered completely in vigour and much in habit by the scions they respectively supported. The reciprocal effects of the stock on the scion has perhaps never been more clearly shown than in these two pictures.

PLATE XI



Top row. Sangtara oranges from a tree budded on the citron or "galgal" (*C. Medica*, Linn.). The fruits were exceedingly coarse in appearance and, as they had very little juice, they were unsaleable. The average number of seeds per fruit was eight.

Second row. Sangtara oranges from a tree budded on the "sour" orange or "khatta" (*C. Aurantium*, Linn.). The fruits were fairly juicy and the skin thin and tight for this class of fruit. The flavour was quite good. The average number of seeds per fruit was nine.

Third row. Sangtaras from a tree budded on the "rough lemon", "khatti" or "kharna" (*C. Limonium*). Oranges on this stock closely resembled those produced by the "sour orange" stock. The average number of seeds per fruit was ten.

Fourth row. Oranges from a tree budded on the "sweet lime", "mitha" or "sharbete" (*C. Limetta*). On this stock the fruits produced were larger and better in flavour than those on any other stock. The oranges were inclined to be too loose in skin and somewhat coarse in appearance.

VI. Summary of Conclusions.

The Malta.

Of all the orange stocks which are used by nurserymen in North-West India, the "rough lemon," "khatti" or "kharna" (*C. Limonum*, Osbeck, var.) is the one which gives greatest vigour and fruitfulness to the Malta.

The "sweet lime," "mitha" or "sharbete" (*C. Limonum*, var.), is suitable for the Malta in the small private garden only, where a dwarf tree with a few oranges of high quality are desired: the stock is unsuitable for the commercial Malta grove.

The citron or "galgal" (*C. Medica*, Linn.) and the "sour orange" or "khatta" (*C. Aurantium*, Linn.) are not suitable stocks for the Malta in North-West India.

The Sangtara.

In almost all respects the "sweet lime", "sharbete" or "mitha" (*C. Limonum*, var.) is the best stock for the Sangtara.

The "rough lemon," "khatti" or "kharna" (*C. Limonum*, Osbeck, var.) and the citron or "galgal" (*C. Medica*, Linn.) are not suitable stocks for the Sangtara.

The stock and scion influence each other profoundly in producing vigour and fruitfulness in the orange tree, and in developing colour, shape, size, quality, flavour, beauty and seedlessness in the fruit.

Tests of stocks should be made wherever the orange is grown in India.

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