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EFFECT OF ORGANIC SUBSTANCES ON YIELD AND ECONOMIC FEASIBILITY OF MANDARIN

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ABSTRACT

A field experiment was carried out during the year 2021-22 and 2022-23 on 12 years old mandarin plants at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar. The experiment was consisting of 21 treatments of different organic source of NPK *viz*., vermicompost, cotton fortified vermicompost, *neem* cake, cotton cake, mustard cake and bio fertilizers such as PSB and VAM with three levels of recommendation dose of fertilizers. The experiment was laid out in randomized block design with three replications. Treatment T_9 (75% RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB) was found best with regards to maximum increase in number of fruits per plant, fruit yield per plant and per hectare Similarly, maximum gross return of Rs. 4,03,770/ha which was Rs. 1,28,760/ha excess over control. Further, the highest net profit (Rs. 73,299/ha or 27.19 per cent over control) was also estimated at this treatment which was 46.82 per cent higher than control in pooled analysis.

Key words : Nitrogen, Economics, Nutrient, Organic, Yield.

Introduction

Mandarin (*Citrus reticulata* Blanco.) is considered to be one of the most important cultivated species among citrus fruits. It belongs to the family Rutaceae and sub-family Aurantioideae. In the genus of citrus, there are 162 species which is extensively grown in the tropical and sub-tropical regions of the worldand most of the species are originated from South East Asia, mainly India and China.

"Nagpur Mandarin" is one of the finest varieties and very popular in India as well as in world for its good qualitative fruits. It is a highly polyembryonic species in nature having medium sized upright trees with evergreen growth habit and relatively few thorns. Leaves are medium in size, lanceolate in form having prominent midrib and long narrowly winged petioles. Flowers are small to medium, and fruit are globose or sub-globose in shape having pale orange yellow colour peel, which is easily separating from the segments. Seeds are small, pointed with green cotyledons (10 to 15 in numbers). Its single fruit contains 10 to 12 segments. Fruit has mild flavour, excellent quality and juicy with 10-12^0 Brix TSS and 0.5 to 0.9 per cent acidity. Mandarin juice is refreshing and nutritious due to its ascorbic acid content, sweet acid taste and appealing colour.

Integrated nutrient management refers to the maintenance of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrient in an integrated manner. (Lal and Dayal, 2014). It infuses long term sustainability in the productivity level because of availability of nutrients in soil for next season crop. Incorporation of organic fertilizers is a common practice to improve yield of many fruit crops. Application of organic manures and bio fertilizers are not only sustained high yields for multiple years but also help in improving physical, chemical and microbial health of soil (Bakshi *et al.*, 2018). The main objective of integrated nutrient management is the

adjustment of plant nutrient supplywith proper combination of chemical fertilizers, organic manure and bio-fertilizers suitable to social, economic and ecological system (Bhandari *et al*., 2018).

Materials and Methods

Location

Jhalawar district is located at $23^0$4' to $24^0$52' N-Latitude and $75^0$29' to $76^0$56' E-Longitude in South-Eastern, Rajasthan. Agro-climatically, the district falls in Zone V, known as Humid South Eastern Plain. About 84.22 per cent population of the district is rural whose main occupation is agriculture. Average rainfall in the region is 954.7 mm. Maximum temperature range in the summer is 43^0 C- 48^0C and minimum 3^0 C - 5^0C during winter. Agriculture and forest lands occupy 73.5 per cent area, respectively in the district.

Plant material

Twelve years old mandarin cv. 'Nagpur' plants of uniform size and growth were selected at Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar for experimentation. For this experiment, a total of 126 plants were selected from the mandarin "A" block during the year 2021-22 and 2022-23.

Experimental details

The field experiment was laid out in simple Randomized Block Design (RBD) with three replications. The experimentation comprising of 21 treatment combinations (T_0- Control (100% RDF), T_1-75% RDF, T_2-75% RDF + 10 kg VC, T_3- 75% RDF + 10 kg CFV, T_4- 75% RDF + 7.5 kg NC, T_5- 75% RDF + 7.5 kg CC, T_6- 75% RDF + 7.5 kg MC, T_7- 75% RDF + 50 g PSB, T_8- 75% RDF + 50 g VAM, T_9- 75% RDF + 10 kg VC + 7.5 kg NC + 50 g PSB, T_{10}- 50% RDF + 50 g PSB, T_{11}- 50% RDF + 50 g VAM, T_{12}- 50% RDF + 10 kg VC + 50 g PSB, T_{13}- 50 % RDF + 10 kg VC + 50 g VAM, T_{14}- 50% RDF + 7.5 kg NC + 50 g PSB, T_{15}- 50% RDF + 7.5 kg NC + 50 g VAM, T_{16}- 50% RDF + 7.5 kg CC + 50 g PSB, T_{17}- 50% RDF + 7.5 kg CC + 50 g VAM, T_{18}- 50% RDF + 7.5 kg MC + 50 g PSB, T_{19}- 50% RDF + 7.5 kg MC + 50 g VAM, T_{20}- 50% RDF + 10 kg VC + 7.5 kg NC + 50 g PSB). The Nagpur Mandarin plants were planted at a distance of 6 × 6 m^2. The trees were Twelve years old. The treatments consisted of different organic source namely vermicompost, cotton fortified vermicompost, *neem* cake, cotton cake, mustard cake and bio fertilizers such as PSB and VAM with three levels of recommendation dose of fertilizers. For application of manure and fertilizers the top soil around the tree (equal to the leaf canopy of the tree) is dug up to 30 cm and the fertilizers were uniformly mixed into the soil, then which was leveled. Irrigation is supplied immediately after fertilizer application. The required quantity of inorganic fertilizers @ 300: 200: 250 NPK g/plant (full dose of P_2O_5 and K_2O and half does of Nitrogen) were applied during the month of June by broadcasting under the spread of trees, 30 cm away from the trunk and mixed with soil. Remaining half dose of Nitrogen was applied at the fruit set stage. The whole amounts of the organic manure were applied as a basal dose on during the month of June. The required quantity of oilcakes were powdered and applied to the treatment plant. Bio fertilizers such as VAM and PSB were applied through soil inoculation on the onset of Monsoon.

Number of fruits per plants was recorded by counting the number of fruits per tree at the time of harvesting. Yield per plants was recorded by mature fruits were harvested periodically in each treatment separately and the weight was recorded with the help of single pan balance. Then the total yield (kg / plant) was calculated. The yield of fruits per ha was calculated by multiplying the yield of fruits per plant with number of plants per ha *i.e.*, 278 plants / ha in square planting system spacing 6×6 m. The relative economics of different organic and inorganic sources of nutrient treatments were determined on the plant basis of cost of treatment and yield of fruit per plant and per ha. The net income was decided by subtracting the treatment cost from gross income. It was expressed on net excess income over control. The percent increase in net profit over control was calculated. Treatment-wise cost of cultivation was worked out. The total expenditure on cultivation and management of crop was recorded in terms of rupees and per hectare cost of cultivation was calculated. The gross monetary returns per hectare was worked out considering the average prevailing price for mandarin average @ 30Rs/kg and the net returns were calculated by subtracting the cost of cultivation from gross returns and B: C ratio was worked out by using following formula:

$$\text{Benefit: cost ratio} = \frac{\text{Gross monetary returns (Rs ha}^{-1})}{\text{Cost of cultivation (Rs ha}^{-1})}$$

Results

Number of fruits/plants

From the data in Table 1 further reveal that, amount of fruits/plant of Nagpur Mandarin increased significantly with the application of different organic and inorganic sources of NPK. The maximum number of fruits/plant (315.83), (318.33) and (317.08) were recorded with

Table 1 : Effect of integrated nutrient management on number of fruits/plant of mandarin (*Citrus reticulata* Blanco.) cv. Nagpur Mandarin.

Treatments	Number of fruits / plants		
	2021-22	2022-23	Pooled
T_0	280.83	282.67	281.75
T_1	279.00	280.50	279.75
T_2	289.83	292.00	290.92
T_3	288.83	290.83	289.83
T_4	295.50	298.00	296.75
T_5	297.50	300.00	298.75
T_6	293.33	295.83	294.58
T_7	286.83	289.00	287.92
T_8	286.50	288.67	287.58
T_9	315.83	318.33	317.08
T_{10}	283.83	285.67	284.75
T_{11}	283.00	284.83	283.92
T_{12}	298.83	301.33	300.08
T_{13}	299.67	302.17	300.92
T_{14}	307.50	310.00	308.75
T_{15}	306.50	309.00	307.75
T_{16}	311.17	314.17	312.67
T_{17}	309.83	312.67	311.25
T_{18}	303.83	306.33	305.08
T_{19}	303.50	306.00	304.75
T_{20}	314.67	317.67	316.17
SE (m) ±	**5.07**	**3.94**	**4.71**
C.D. at 5%	**14.51**	**11.28**	**13.48**

treatment T_9 (75% RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB) which was closely followed by T_{20} (50 % RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB) having values of (314.67), (317.67 %) and (316.17%) during both the years 2021-22, 2022-23 and in pooled analysis. Treatment T_{16} (50% RDF + 7.5 kg Cotton Cake + 50 g PSB) and treatment T_{17} (50% RDF + 7.5 kg Cotton Cake + 50 g VAM) were also found at par. However, the minimum number of fruits/ plant (279), (280.50) and (289.75) was recorded under T_1 (75 % RDF) during 2021-22, 2022-23 and in pooled analysis, respectively.

Yield per plant (kg)

From the data in Table 2 showed that the yield per plant (kg) of Nagpur mandarin was significantly influenced by the application of different organic and inorganic sources of NPK during 2021-22 and 2022-23. The maximum yield per plant (47.79 kg), (49.03 kg) and (48.41 kg) was recorded under the treatment T_9 (75% RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB).

Table 2 : Effect of integrated nutrient management on yield per plant and yield per hectare of mandarin (*Citrus reticulata* Blanco.) cv. Nagpur Mandarin

Treatments	Yield per plant (kg)			Yield per hectare (quintal)		
	2021 -22	2022 -23	Pooled	2021 -22	2022 -23	Pooled
T_0	32.57	33.37	32.97	90.55	92.78	91.67
T_1	31.70	32.28	31.99	88.13	89.74	88.93
T_2	36.69	37.63	37.16	102.00	104.61	103.31
T_3	36.67	37.59	37.13	101.95	104.51	103.23
T_4	39.54	40.59	40.07	109.92	112.85	111.38
T_5	38.44	39.46	38.95	106.86	109.70	108.28
T_6	38.68	39.71	39.20	107.54	110.41	108.97
T_7	35.77	36.69	36.23	99.44	102.00	100.72
T_8	35.41	36.32	35.87	98.45	100.98	99.71
T_9	47.79	49.03	48.41	132.86	136.32	134.59
T_{10}	34.40	35.24	34.82	95.63	97.97	96.80
T_{11}	34.19	35.03	34.61	95.04	97.38	96.21
T_{12}	40.93	42.02	41.48	113.79	116.81	115.30
T_{13}	41.24	42.33	41.79	114.65	117.69	116.17
T_{14}	45.08	46.27	45.67	125.33	128.62	126.98
T_{15}	44.45	45.62	45.04	123.57	126.82	125.20
T_{16}	43.81	45.03	44.42	121.79	125.18	123.48
T_{17}	43.27	44.45	43.86	120.29	123.57	121.93
T_{18}	43.59	44.74	44.17	121.19	124.38	122.78
T_{19}	43.08	44.22	43.65	119.76	122.92	121.34
T_{20}	47.01	48.31	47.66	130.68	134.30	132.49
SE (m) ±	**1.95**	**3.29**	**2.49**	**1.90**	**3.01**	**1.43**
C.D. at 5%	**5.59**	**9.41**	**7.14**	**5.45**	**8.61**	**4.09**

T_{20} (50% RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB) was also found at par having values of (47.01 kg), (48.31 kg) and (47.66 kg) during both the years 2021-22, 2022-23 and in pooled analysis, respectively. Treatment T_{14} (50% RDF + 7.5 kg *Neem* Cake + 50 g PSB), T_{15} (50 % RDF + 7.5 kg *Neem* Cake + 50 g VAM), T_{16} (50% RDF + 7.5 kg Cotton Cake + 50 g PSB) and treatment T_{17} (50% RDF + 7.5 kg Cotton Cake + 50 g VAM) were also found at par. However, the minimum yield per plant (31.70 kg), (32.28 kg) and (31.99 kg) was recorded under T_1 (75% RDF) during 2021-22, 2022-23 and in pooled analysis, respectively.

Yield per hectare (quintal)

The maximum yield per hectare (132.86 quintal), (136.32 quintal) and (134.59 quintal) was recorded under the treatment T_9 (75% RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB) which was closely followed by T_{20} (50% RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB) having values of (130.68

Table 3 : Economic feasibility of integrated nutrient management in mandarin (*Citrus reticulata* Blanco.) cv. Nagpur Mandarin.

Treatments		Total treatment cost/ ha.	Additional treatment cost / ha over control	Total cost of cultivation	Yield (Qt./ha)	Gross return (@ Rs. 30/kg)	Net Profit	Excess income over control	Net profit due to treatment over control	% increase in yield over control	% Increase in net profit over control	B:C ratio
1.	T_0	5407.10	0	25407.10	91.67	275010	269603	-	-	-	-	10.8
2.	T_1	4031.00	-1376.1	24031.00	88.93	266790	262759	-8220	-12251.00	-2.99	-4.54	11.1
3.	T_2	17931.00	12523.9	35931.00	103.31	309930	291999	34920	16989.00	12.70	6.30	8.6
4.	T_3	17931.00	12523.9	35931.00	103.23	309690	291759	34680	16749.00	12.61	6.21	8.6
5.	T_4	37391.00	31983.9	54391.00	111.38	334140	296749	59130	21739.00	21.50	8.06	6.1
6.	T_5	77006.00	71598.9	94006.00	108.28	324840	247834	49830	-27176.00	18.12	-10.08	3.5
7.	T_6	56156.00	50748.9	73156.00	108.97	326910	270754	51900	-4256.00	18.87	-1.58	4.5
8.	T_7	8201.00	2793.9	23201.00	100.72	302160	293959	27150	18949.00	9.87	7.03	13.0
9.	T_8	8201.00	2793.9	23201.00	99.71	299130	290929	24120	15919.00	8.77	5.90	12.9
10.	T_9	55461.00	50053.9	70461.00	134.59	403770	348309	128760	73299.00	46.82	27.19	5.7
11.	T_{10}	6880.50	1473.4	25880.50	96.80	290400	283520	15390	8509.50	5.60	3.16	11.2
12.	T_{11}	6880.50	1473.4	25880.50	96.21	288630	281750	13620	6739.50	4.95	2.50	11.2
13.	T_{12}	20780.50	15373.4	37280.50	115.30	345900	325120	70890	50109.50	25.78	18.59	9.3
14.	T_{13}	20780.50	15373.4	37280.50	116.17	348510	327730	73500	52719.50	26.73	19.55	9.3
15.	T_{14}	40240.50	34833.4	56240.50	126.98	380940	340700	105930	65689.50	38.52	24.37	6.8
16.	T_{15}	40240.50	34833.4	56240.50	125.20	375600	335360	100590	60349.50	36.58	22.38	6.7
17.	T_{16}	79855.50	74448.4	98855.50	123.48	370440	290585	95430	15574.50	34.70	5.78	3.7
18.	T_{17}	79855.50	74448.4	98855.50	121.93	365790	285935	90780	10924.50	33.01	4.05	3.7
19.	T_{18}	59005.50	53598.4	75005.50	122.78	368340	309335	93330	34324.50	33.94	12.73	4.9
20.	T_{19}	59005.50	53598.4	75005.50	121.34	364020	305015	89010	30004.50	32.37	11.13	4.9
21.	T_{20}	54140.50	48733.4	69140.50	132.49	397470	343330	122460	68319.50	44.53	25.34	5.7

B: C ratio - Gross return /Total cost of cultivation (Treatment cost + additional cost of cultivation).

quintal), (134.30 quintal) and (132.49 quintal) during both the years 2021-22, 2022-23 and in pooled analysis respectively. However, the minimum yield per hectare (88.13 quintal), (89.74 quintal) and (88.93 quintal) was recorded under T_1 (75% RDF) during 2021-22, 2022-23 and in pooled analysis, respectively.

Economics of the treatment used

The economics of different integrated nutrient management used in the present investigation are calculated and presented in Table 3. The economic feasibility of various treatments clearly showed that T_9 (75% RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB) treatment has resulted the maximum gross return of Rs. 4,03,770/ha which was Rs. 1,28,760/ha excess over control. Further, the highest net profit Rs. 3,48,309/ha was estimated with the same treatment which was 46.82 per cent higher in yield and 27.19 percent higher in net profit than control. T_{20} (75% RDF + 10 kg Vermicompost + 7.5 kg *Neem* Cake + 50 g PSB) was found at par having gross return of Rs. 3,97,470/ha, which was Rs. 1,22,460/ha excess over control.

B:C ratio of the treatment used

The B:C ratio of different integrated nutrient management used in the present investigation are calculated and presented in Table 3. The B:C ratio of various treatments clearly showed that T_7 (75% RDF + 50 g PSB) which was closely followed by T_8 (75% RDF + 50 g VAM), T_{10} (50% RDF + 50 g PSB) and T_{10} (50% RDF + 50 g VAM).

Discussion

The increase in percentage of fruit set and fruit retention are the most imperative characters which directly imitate on yield. Increase in number of fruits per plant and fruit weight consequently increases in total production. This might be due to the optimum supply of plant nutrients during entire period of fruit growth, ultimately resulting in accumulation of more photosynthesis leading to more fruit development and yield of fruits. The integrated application of inorganic fertilizers and organic manures might have supplied adequate amount of nutrients and favoured the metabolic and auxin activity which resulted better values for yield attributing traits. Similar results were observed by Ahlawat *et al.* (2000) in ber. Same treatments also improved soil condition which might have resulted into better development of plants. Oil cakes are rich in plant nutrients and in addition to that, it contains important alkaloids, which have nitrification inhibiting properties and releases nitrogen slowly. Thus, apart from the nutrient content in oil cakes, the retention capacity of nutrients to a prolonged period and its balanced availability might have resulted in better yield. (Dhomane and Kadam, 2013). Similar results were also found in respect to yield attributing characters by Lal and Dayal (2014) in acid lime, Babhulkar *et al*. (2017) in nagpur mandarin, Bhandari *et al*. (2018) in acid lime, Mamindla and Prasad (2017) in guava.

Treatments comprising organic manures and biofertilizers in combination with inorganic fertilizers had a higher cost of cultivation but higher yields obtained maximized the benefit resulting in a higher benefit: cost ratio. Similar results were reported by Bakshi *et al*. (2018) in Kinnow and Kumar *et al.*, (2018) in Strawberry with the combined application with organic manures.

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Declaration of competing interest

No interests to declare.

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