



Research Article

Assessment and Economic Returns of Lemons at District Naushahro Feroze, Sindh, Pakistan

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Abstract | District Naushahro Feroze of Sindh also known as “Sahatia Pargana” is the main hub and robust zone of Lemon cultivars with rich productivity. The research study was carried out to study the economic feasibility and production potential of Lemons from five respective talukas of District Naushahro Feroze-Sindh, 2021. The maximum per hectare net return and benefit-cost ratio from taluka Kandiaro in PKR, was calculated at net profit Rs; (228998/ha), (1.70), in pesticide applied module and (197065/ha), (2.74), non-pesticide module with net income followed by Mehrabpur, (213366/ha), (1.54), (186080/ha), (2.54), Bhiria, (194077/ha), (1.32), (176972/ha), (2.40), Naushahro Feroze, (164287/ha), (1.17), (135057/ha), (1.60), and Moro (134452/ha), (0.99), (99789/ha), (1.21), respectively. In this region, citriculture is the trademark industry and Citrus limon fruits are regarded as table fruit, rich content of vitamin “C” appreciated due to delicious taste with high economic and medicinal value. The present research work indicates the per hectare lemon benefit cost ratio, gross returns and net returns were benefited to Lemon cultivation in this area and proved that the Lemon growers earning profit in changing situation. Previously there is no such type of comprehensive assessment study on Lemons and its cost benefit has been taken in this area. Considering the aforementioned facts, this piece of work has been taken with the objective to evaluate the per hectare economic assessment of the lemons. So, it is dire needed to conduct the research study on lemons to benefit the livelihood and pave the way for new researchers. Therefore, Integrated Pest Management strategies should be strongly recommended to secure and enhance the citriculture industry.

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Introduction

Citrus, a symbol of beauty, and most important consumed fruits grown in tropical and subtropical regions of the world (Adenaike and Onyukwo, 2021),

with unique diversity and 3rd largest industry among other fruits in the world (Sarada *et al.*, 2014). Citrus varieties are originated in South East Asia and extended from North-east India to North-central China (Dafna, 2017), Burma, Indonesia, Caledonia,

Bangladesh, Philippines and Pakistan (Prashant *et al.*, 2017). Lemons fruits are vulnerable, widely preferred, delightful in taste and main exportable commodity District key position in economic perspective of the district Naushahro Feroze (Mangrio and Sahito, 2022), and most of the citrus growers of this area are engaged by lemon crop as their earning live hood (Mangrio *et al.*, 2020). The citrus fruits are considered as famine fun food with wide distribution and Pakistan is the top ten in the world in terms of citrus area cultivation (Usman *et al.*, 2008).

Citrus fruits are more popular owing to their thirst-quenching quality, anti-viral, anti-diabetic, anti-inflammatory, anti-oxidant, anti-fungal, and anti-ulcer medicinal properties (Rafique *et al.*, 2020). Due to the presence of alkaloid constituent in lemon flowers, stem, leaves and roots act against anti-bacterial, anti-cancer (Oikeh *et al.*, 2016). Lemons possess variety phytochemicals *viz.*, carotenoids, limonoids, citric acid, pyridoxine, biotin, thiamine, folic acid, nicotinic acid, choline, riboflavin, flavanones and pantothenic acid (Singh *et al.*, 2019). In addition to high nutritional value and high amount of vitamin “C” makes Lemons more popular with great status among all other fruits in the world (Kundu *et al.*, 2018). The oil of the lemon promotes clarity of thoughts, reduces face wrinkles, respiratory distress, cardiovascular disorder, kidney stone, blood sugar level and creates restriction against human liver cancers cells (Berk, 2016). Lemons fruit act as in treating biliousness, asthma, heart burn, colds, liver complaints, rheumatism, diphtheria, cough, fever and production of WBCs (Sanofar, 2014).

Citrus is the leading fruits of Pakistan holding the highest export share with great economic value and their demand is going to increase globally (Donkersley *et al.*, 2018), but bad impact on consumers demand, citrus value chain, and price transparency hinders mainly caused by old-fashioned marketing system also socioeconomic factors, wide use of pesticides and pathogens are the major productivity constrains (Burhan *et al.*, 2018). The *Scirtothrips citri*, *Diaphorina citri*, *Toxoptera citricida*, leaf miners, trunk borers, mealy bugs, and aphids are the major limiting causative agents (Rupak and Sikha, 2019), but *Papilio demoleus* is the key pest of lemon orchards (Mangrio and Sahito, 2023). The attention is needed on quality development, strength marketing, high post harvested measures, advanced facilities, investments and introduction of commercial varieties for maximum

yield productivity and economic returns (Burhan *et al.*, 2018).

Besides providing livelihood economic returns to the growers and unique characteristics, *Citrus limon* is a profitable business and regarded as the valuable commodity in Pakistan but unfortunately citrus marketing is totally in the hands of private sector and partially regulated by government. With the application of multidisciplinary approaches, proper pest management, diagnosis methods, modern agronomic techniques, parasitoids augmentation, cultivation suitable areas, ecological knowledge, application of botanical insecticides, pathogenic free planting materials, eco-friendly dynamic management, and insect vectors for control measures can offer an effective and safe pathway in *Citrus limon* productivity enhancement.

The changing climatic condition and fertile soil of Pakistan are in favour of citrus production but poor sapling quality, traditional technologies, pest attack, adulteration of insecticides, fertilizers, and production export are the major constrains of lemons. The control of weed in lemon orchards, conserve organic matter and moisture of soils from leaching of nutrients is strictly needed for maximum lemon yield production. In present study it was observed too difficult to compare the gross and net returns from all talukas of the given district because of soil type, fruit quality and price fluctuations.

Materials and Methods

Geographical description of the study area

The study site has sub-tropical climate with extremely hot summer and mild winter. The pre-monsoon starts from March to April, and monsoon sets normally from the month of June till September almost throughout the country. The national average rainfall was recorded 242.3 mm, the average annual temperature remained 23.43°C, and research conducted year remained the seventh-warmest year in the history of Pakistan. The study area mostly contains fertile lands situated at 26°50'0 N and 68°7'0 E, 44.55 m above the sea level. District Naushahro Feroze borders Khairpur in the north-east, Dadu in the west, Larkana north-west, and Nawabshah south-east as shown in (Figure 1).

Data collection strategy

For understanding the per hectare benefit-cost ratio of

lemon orchards and fruits, the questionnaire proforma was developed. A total of (n=100) questionnaire were formulated and from each taluka (n=20) proforma was filled face to face responses of the respondents/ lemon growers during, 2021. The (n=10) respondents from each taluka were individually interviewed about per hectare pesticide with gross return and net return and formulated as (module-1). The (n=10) lemon growers were interviewed about per hectare non-pesticide and formulated as (module-2). Generally, the lemon plants bear lemons after the passing of two years but in this research study the all expenses and productivity of one year data of the (n=06) year old matured lemon plants per hectare from all five talukas were gathered.



Figure 1: Different talukas of study area located at District, Naushahro Feroze-Sindh.

Benefit cost analysis

The questionnaire proforma contained columns such as; lemon growers age, marital status, education, income source, farming experience, power source, soil type, method of cultivation, per hectare lemon plants, plant to plant distance, fertilizers cost, farmyard manure cost, weeding, irrigation, pesticide cost, annual labour charges, all other expenses and average yield/ fruit boxes per hectare with net income. All the columns of the proforma were filled authentic information of per hectare all expenses and net returns were gathered through personal lemon grower’s interviews by following the described methodology of [Burhan et al. \(2004\)](#).

The economic assessment of lemon orchards

The economic assessment of lemons and analysis of investment carried out benefit-cost during the period of study. Per hectare, all expenses from each of the talukas individually converted in to PKR. The total expenditure and monetary returns per hectare were worked out as follows:

$$\text{Gross return} = \frac{\text{Value of yield (produce) of lemon fruits}}{\text{per/ha}}$$

$$\text{Net return} = \frac{\text{Gross return per/h total cost of cultivation}}{\text{per/ha}}$$

In order to calculate the benefit-cost ratio for different treatments was worked out on the price of expenditure inputs and marketable prices by using the formula, and it is expressed in ratio as: Benefit-cost ratio = Net returns (Rs./ha) Cost of cultivation (Rs./ha).

Data analysis

The obtained data from each of the talukas were entered into the computer by using the MS excel software package. The prices of each component were collected according to the market selling price from the citrus growers. The descriptive analysis of overall net cost and net returns of per hectare Lemons were statistically analyzed by the application of statistical powerful software, SPSS.

Results and Discussion

Benefit-cost ratio of lemon orchards and fruits at Taluka Kandiaro

The per hectare detailed cost description of all expenditures, gross and net returns from each of the talukas gathered through the source of the lemon growers. The per hectare mean cost of fertilizers from taluka Kandiaro was calculated at (42018), irrigation/ tube well (14400), labour charge (15632), weeding (18500), harvest (20200), pesticide (15850), health cure (7650), with total expenses (134250), per box average price (605), total lemon boxes income price (363248) with net income (228998) in (module-1) pesticide applied per/ha. While as, the cost of farmyard manure was recorded (11550), irrigation/ canal cost (11900), labour charge (12050), weeding (12600), harvest (20350), tobacco (1250), health cure (2200), total expenses (71900), per box average price (520.50), lemon fruit boxes total income price (268965), with net income (197065) in (module-2) non-pesticide applied per/ha, further validation shown in (Table 1).

Benefit-cost ratio of lemon orchards and fruits at Taluka Mehrabpur

From taluka Mehrabpur the overall mean cost of *C. limon* per hectare of fertilizers was recorded (39125), irrigation water through tube well source (19200), labour charge (13250), wedding (13750), harvest

(21825), cost of pesticide (22625), health cure (8500), per hectare total expenses (138275), average per/box price (785), total boxes price (351641), with net income (213366) in (module-1). While as; the overall all mean cost of fertilizers/farmyard manure was calculated (12650), irrigation/canal cost (12250), labour charge (13751), weeding (11600), harvest (19900), garlic (1630), health cure (1260), per hectare total expenses (73041), per box average price (690), total boxes price (259121), with net income (186080) in (module-2), respectively. Further justification is given in (Table 2).

Table 1: Per/ha cost comparison modules with overall mean benefit-cost ratio of lemon at taluka Kandiaro during, 2021 (PKR).

Pesticide application	Module-1	Non-pesticide application	Module-2
Particulars cost	PKR	Particulars cost	PKR
Fertilizers	42018	Fertilizers/FYM	11550
Irrigation/canal/tube well	14400	Irrigation/canal/tube well	11900
Labour charge	15632	Labour charge	12050
Weeding	18500	Weeding	12600
Harvest	20200	Harvest	20350
Pesticide	15850	Tobacco	1250
Health cure	7650	Health cure	2200
Av. boxes price	605	Av. boxes price	520.50
Total price/ha	363248	Total price/ ha	268965
Total expenses	134250	Total expenses	71900
Net income/ha	228998	Net income/ ha	197065

Benefit-cost ratio of lemon orchards and fruits at Taluka Bhiria

The cost state benefit-cost ratio of per hectare from taluka Bhiria with overall mean cost of fertilizers was calculated (43260), irrigation/tube well (19475), labour charge (16255), weeding (16050), harvest (17625), pesticide (22965), health cure (10595), per hectare mean expenses (146225), average per box price (714.5), total boxes price (340302), with net income (194077) in (module-1). While as; the per hectare mean cost of farmyard manure was counted (10250), irrigation canal (13450), labour charge (14250), weeding (10250), harvest (20550), neem oil and detergent (3100), health cure (1800), per hectare mean expenses (73650), average per box price (622.50), total boxes price (250622), with net income (176972) in (module-2), respectively shown in (Table 3).

Table 2: Per/ha cost comparison modules with an overall mean benefit-cost ratio of lemon at taluka Mehrapur during, 2021 (PKR).

Pesticide application	Module-1	Non-pesticide application	Module-2
Particulars cost	PKR	Particulars cost	PKR
Fertilizers	39125	Fertilizers/FYM	12650
Irrigation/canal/tube well	19200	Irrigation/canal/tube well	12250
Labour charge	13250	Labour charge	13751
Weeding	13750	Weeding	11600
Harvest	21825	Harvest	19900
Pesticide	22625	Garlic	1630
Health cure	8500	Health cure	1260
Av. boxes price	785	Av. boxes price	690
Total price/ ha	351641	Total price/ ha	259121
Total expenses	138275	Total expenses	73041
Net income/ ha	213366	Net income/ ha	186080

Table 3: Per/ha cost comparison modules with an overall mean benefit-cost ratio of lemon at taluka Bhiria during, 2021 (PKR).

Pesticide application	Module-1	Non-pesticide application	Module-2
Particulars cost	PKR	Particulars cost	PKR
Fertilizers	43260	Fertilizers/FYM	10250
Irrigation/canal/tube well	19475	Irrigation/canal/tube well	13450
Labour charge	16255	Labour charge	14250
Weeding	16050	Weeding	10250
Harvest	17625	Harvest	20550
Pesticide	22965	Neem oil & detergent	3100
Health cure	10595	Health cure	1800
Av. boxes price	714.5	Av. boxes price	622.50
Total price/ ha	340302	Total price/ ha	250622
Total expenses	146225	Total expenses	73650
Net income/ ha	194077	Net income/ ha	176972

Benefit-cost ratio of lemon orchards and fruits at Taluka Naushahro Feroze

From taluka Naushahro Feroze the overall *C. limon* per hectare benefit-cost ratio of fertilizers was counted (43735), irrigation tube well source (22700), labour charge (10550), weeding (15900), harvest (21900), pesticide (18050), health cure (7100), per hectare mean expenses (139935), average box price (670), total boxes price (304222), with net income (164287) in (module-1). Similarly, overall mean cost of fertilizers and farmyard manure was calculated (14365), irrigation through canal source (20400), labour charge (15250), weeding (11900), harvest

(19700), tobacco (1200), health cure (1400), per hectare mean expenses (84215), average box price (586.25), total boxes price (219272) with net income (135057) per hectare in (module-2), respectively, the justification is given in (Table 4).

Table 4: Per/ha cost comparison modules with an overall mean benefit-cost ratio of lemon at taluka Naushahro Feroze during, 2021 (PKR).

Pesticide application	Module-1	Non-pesticide application	Module-2
Particulars cost	PKR	Particulars cost	PKR
Fertilizers	43735	Fertilizers/FYM	14365
Irrigation/canal/ tube well	22700	Irrigation/canal/ tube well	20400
Labour charge	10550	Labour charge	15250
Weeding	15900	Weeding	11900
Harvest	21900	Harvest	19700
Pesticide	18050	Tobacco	1200
Health cure	7100	Health cure	1400
Av. boxes price	670	Av. boxes price	586.25
Total price/ ha	304222	Total price/ ha	219272
Total expenses	139935	Total expenses	84215
Net income/ ha	164287	Net income/ ha	135057

Benefit-cost ratio of lemon orchards and fruits at Taluka Moro

From taluka Moro, the overall mean expenses of the fertilizers was calculated (42127), irrigation through tube well (22900), labour charge (9670), weeding (15760), harvest (20890), pesticide (13395), health cure (10615), per hectare mean expenses (135357), average box price (708.5), total box price per hectare (269809), with net income (134452) in (module-1). Simultaneously, the overall men expenses of farmyard manure was reported (13500), irrigation through canal source (15800), labour charge (17170), weeding (15300), harvest (18040), garlic (1500), health cure (1130), per hectare mean expenses (82440), average box price (611.50), per hectare total box price (182229), with net income (99789) in (module-2), further described in (Table 5).

Benefit-cost ratio of lemon orchards and fruits from five talukas at district Naushahro Feroze

The District Naushahro Feroze is regarded as the main hub of *Citrus limon* production and also master of many fruits. The overall mean expenses of fertilizers cost was recorded (42053), irrigation (19735), labour charge (13275), weeding (15992), harvest (20488), pesticide (18577), health cure (9892), per hectare

mean expenses (140012), average box price (696.6), total box price per hectare (325844.4), with per hectare net income (185832.4) from five talukas of the district in pesticide applied (module-1). While as; the overall mean cost of fertilizer/farmyard manure expenses was counted (12463), irrigation cost (14760), labour charge (14494.2), weeding (12330), harvest (19708), bio-pesticides (1736), health cure (1558), per hectare mean expenses (77049.2), average box price (606.15), total per hectare box price (236041.8), with net income (158992.6), Pakistani rupees from five talukas of the district in non-pesticide (module-2), further justifications are given in (Table 6).

Table 5: Per/ha cost comparison modules with an overall mean benefit-cost ratio of lemon at taluka Moro during, 2021 (PKR).

Pesticide application	Module-1	Non-pesticide application	Module-2
Particulars cost	PKR	Particulars cost	PKR
Fertilizers	42127	Fertilizers/FYM	13500
Irrigation/canal/ tube well	22900	Irrigation/canal/ tube well	15800
Labour charge	9670	Labour charge	17170
Weeding	15760	Weeding	15300
Harvest	20890	Harvest	18040
Pesticide	13395	Garlic	1500
Health cure	10615	Health cure	1130
Av. boxes price	708.5	Av. boxes price	611.50
Total price/ ha	269809	Total price/ ha	182229
Total expenses	135357	Total expenses	82440
Net income/ ha	134452	Net income/ ha	99789

Table 6: Overall per/ha mean cost benefit-cost ratio comparison modules of lemon from five talukas at district Naushahro Feroze during, 2021 (PKR).

Pesticide application	Module-1	Non-pesticide application	Module-2
Particulars cost	PKR	Particulars cost	PKR
Fertilizers	42053	Fertilizers/FYM	12463
Irrigation/canal/ tube well	19735	Irrigation/canal/ tube well	14760
Labour charge	13275	Labour charge	14494.2
Weeding	15992	Weeding	12330
Harvest	20488	Harvest	19708
Pesticide	18577	Bio-pesticides	1736
Health cure	9892	Health cure	1558
Av. boxes price	696.6	Av. boxes price	606.15
Total price/ ha	325844.4	Total price/ ha	236041.8
Total expenses	140012	Total expenses	77049.2
Net income/ ha	185832.4	Net income/ ha	158992.6

The present study was aimed to assess the per hectare expenditure and profitability of Lemons. The climatic condition and soil type of this area found frequently favours for growth of lemon orchards and their productivity. Our result is more or less comparable with the published work of (Hasan *et al.*, 2020), they worked on benefit cost ratio of lemon based agro-forestry systems at Madhupur, India and proved lemon-based agro-forestry systems are more profitable than sole cropping cultivation. Dubey *et al.* (2023), proved optimized foliar application with significant effect of micronutrients on yield attributes and economic feasibility of lemon orchards. Sikha *et al.* (2021), reported that Assam lemon is one of the most prominent commercial citrus fruits and productivity average had increased from 4421kg/ha to 7614kg/ha with 3.4:1 benefit cost ratio. Kaysar *et al.* (2017), worked on the production of the Colombo and Jara lemons at Bangladesh, the highest gross return was found in 5th years old lemon orchards followed by 11th to 15th year old lemon plants. Bukero and Philipos (2018), analysis the benefit cost ratio of Verbena (Lominat) lemons and proved this variety of herbal plants provides the net present value and benefit cost-ratio of 12828.5\$/ha, 10043.6 and 0.2 at fresh bio-mass price of 0.4\$/kg. Sharma *et al.* (2023) discussed economics of plant prepared through air layers of Kazi lime (*Citrus aurantifolia* Swingle) under rainfed conditions and the treatment using 1500 ppm (Indole-3-butyric acid) IBA, soil and sphagnum moss proved to be the most profitable, providing the highest net profit and benefit cost-ratio (Adeel *et al.*, 2014) documented that without intercropping lemon orchards give better production and gross income, net income and benefit cost-ratio without intercropping are much higher than the lemons with intercropping.

Based on the above investigation, it was observed that on the yield and economic feasibility of lemon orchards, with maximum yield per tree (kg), net return, benefit-cost ratio can be was obtained from this area. Because district Naushahro Feroze is the more suitable place in terms of well-furnished agricultural resources, mostly fertile soil, citrus growers keen interest, climatic and seasonal diversity, due to this different lemon cultivars are growing abundantly as a main source of livelihood of the local people of this area. In present work, per hectare information related benefit cost-ratio was gathered from lemons growers at five talukas of district Naushahro Feroze on *Citrus limon* growers about the per hectare benefit-cost ratio.

The maximum per hectare net income from taluka Kandiaro was reported with overall net income per hectare at (228998) pesticide applied module and (197065) from non-pesticide module. From taluka Mehrabpur in pesticide applied module (213366) and non-pesticide module (186080) net income hectare. From taluka Bhiria in pesticide applied module (194077) and non-pesticide module (176972) net income per hectare. From taluka Naushahro Feroze in pesticide applied module (164287) and non-pesticide module (135057) net income hectare and from taluka Moro in pesticide applied module (134452) and non-pesticide module (99789) overall net income per hectare was recorded. The result of this work is more or less comparable with the reported work of (Adeel *et al.*, 2014) documented that without intercropping, citrus yield give maximum production compared with intercropping. The neem seed kernel and carbofuran were used through drip method and resulted higher benefit-cost ratio in NSKE compared to carbofuran (Nagachandrabose *et al.*, 2021).

Conclusions and Recommendations

This study concludes that taluka Kandiaro provided more net income when the benefit-cost ratio was estimated in two modules comparison as a pesticide and non-pesticide application as per hectare followed by the other talukas of the same district. Such as; Mehrabpur, Bhiria, Naushahro Feroze, and Moro, respectively. Lemons farming is a profitable venture can lead to the improvement in small holders farm income and gainful employment to the lemon growers of this area. It is immediate call for more attention should be given by government and other organization to invest in the enterprise. There is no such type of work and adequate scientific research documentary record that shows the updated information regarding the harmful hazards, proper management, and benefit-cost ratio of pests within lemon orchards from District Naushahro Feroze, the Sahati region of Sindh-Pakistan. It is further recommended and dire needed to bring awareness to the local citrus growers of this area, through organizing seminars, newspapers, research publication, television, radio and other sources.

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Novelty Statement

Although, for a long time *Citrus limon* are growing abundantly in District Naushahro Feroze-Sindh, but for its yield and economic returns mostly traditional method and little attention has been given. It is responsibility of the government to take initiative, motivate the citrus growers to adopt new technologies and cultivate better varieties for ensuring better livelihood standards. Again, the state is responsible to strengthen farmer's motivation so that lemon growers through the application of advanced technology increase the lemon production. Furthermore, in future, the comprehensive study should be designed at a large scale to benefit the farmers. The researchers, citrus growers and policymakers are needed to findout the potential lemon cultivars which having high resistance power.

Author's Contribution

Wali Muhammad Mangrio: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, original writing.

Hakim Ali Sahito: Main author of this research manuscript, supervision.

Faheem Ahmed Jatoi: Visualization.

Fahmeeda Imdad Sahito: Writing review and editing.

All authors have read and agreed to the published version of the manuscript.

Data availability statement

All data occurrences are available on request to the corresponding author.

Informed consent statement

The corresponding author accepts all responsibilities for releasing this research work.

Declaration and competing interest

The corresponding author describe that there is no conflict of interest and financial relationship regarding the detailed described work which is presented in this research paper.

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