

# Economic Analysis of Citrus (Kinnow mandarin) during on-Year and Off-Year in the Punjab Province, Pakistan

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## Abstract

Being a perennial crop, citrus is mostly grown in sub-tropical region of the world and in Pakistan it ranks first among fruits in area and production and the Punjab province contribution is 95 percent in area with same level of production. Alternate or biennial bearing is production of heavy and light crops in successive years and most of fruits including citrus are affected by it. The present study was conducted on economic analysis of citrus during on year and off-year in three districts of the Punjab province Pakistan. More alternate bearing was observed in Vehari and TTS districts due to late harvesting. Alternate bearing was observed less in Sargodha due to timely harvesting of Kinnow fruit for export. In Vehari and TTS harvesting linked with domestic markets and was done late than Sargodha. Fruit grades prices were recorded higher in off-year during all harvesting months while fruit availability for export also affected by biennial bearing. During off-year more income from orchards were reduced in Vehari and TTS than Sargodha. The complete randomized block design (RCBD) was used in field study and a survey of farmers, local markets and exporters was performed to analyze its impact on citrus industry.

**Keywords:** Citrus; Economic analysis; Nutrients management

## Introduction

Citrus ranks first position among fruits in area and production in Pakistan and Kinnow mandarin (*Citrus Nobilis* Lour × *Citrus Deliciosa* Tenora) is monopolized cultivated in province of the Punjab [1]. Out of total area under citrus (20.1 thousand hectares), 95% cultivated in the Punjab with sole dominance of Kinnow (91%) in area and production share [2].

During the season 2017-18, Kinnow export has reached maximum in the country history with a volume of 370 thousand tons and value of US\$ 222 million [3] due to on-year bearing and bumper crop at home while less markets competition in world [4]. In last three years, more fruit quality deteriorated due to uneven fruit bearing and high competition with world in citrus fruit exporting markets [5]. Our export is hardly 10-12% of country total production and rest is consumed domestically [6]. Climate change and erratic behavior of weather round the year has direct influence on Kinnow fruit bearing habit and quality in Pakistan while in global markets more preference is given to cosmetic outlook of fruit and regular supply that is main reason of our less export, especially in high returning markets of European Union where our export just fetch 2% [7]. Citrus fruit quality linked with critical phenological growth stages where orchard management, irrigation and pests- diseases control can improve fruit quality [8], but any change in prevailing environmental conditions negatively affect fruit physico-chemical qualities [9] and plant-fruit bearing habit determines regular production trend.

Abiotic and biotic factors intermingled with climate changes that may influence fruit quality and bearing habit of tree and directly affect income of the orchard's owners [10]. Citrus fruit production is directly linked with bearing habit [11] and climate change has triggered alternate bearing in citrus [12]. Climatic variability became extreme [13] that has substantially altered agricultural systems and crop preference [14]. Mitigation strategies of various natures were adopted to minimize its adverse effects [15] but perennial crops like orchard received less research focus except Valencia orange yields in the Southern United States [16]. Citrus being a perennial fruit that long-lived and may change slowly than annual crops and has become more vulnerable to

climate change [17] and ultimately increased trend of irregular bearing in citrus [18].

Many fruit plants produced light and heavy crops in successive years and this phenomenon is known as alternate bearing [19]. It prevents regular supply of fruit in market and has an economic impact on fruits industry. Heavy crop harvested late and reduced flowering for next season and light one harvested earlier to produce more flowers and this tendency led to alternate bearing. Alternate bearing caused more fluctuation in productivity and profitability of orchard from year to year basis, health and vigor of tree deteriorated during on-year, yielded poor fruit quality in on-season and reduction in fruit size and color [20]. Many marketing problems such as glut, irregular supply and prices fluctuation have come from alternate bearing of fruit trees [21].

Alternate bearing has adversely affected supply chain in Pakistan and during on-year; fruit losses were estimated to be about 40 percent [22] and 35 percent [23]. During off-year, supply chain irregularities were less but middlemen profits margin were recorded higher which adversely affected both producers and consumers [24].

Initial work was done on citrus nutrients management, plant protection measures and quality production of fruits but in Pakistan, economics impact of on-year and off-year citrus crop is still to be explored. In this context, present study was conducted in the main citrus groves of the Punjab province three districts namely Sargodha, Toba Tek Singh (TTS) and Vehari and assessed the economic impact

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on the citrus industry of Pakistan during heavy and light crop bearing years.

## Materials and Methods

The present study on economic analysis of Citrus (Kinnow mandarin) during on-year and off-year was conducted in the year (2016-17 and 2017-18 seasons) in three main citrus growing districts of the Punjab province, Pakistan namely Sargodha (32.0837° N, 72.6719° E) altitude 189 m, Toba Tek Singh (30.9727° N, 72.4850° E) altitude 161 m and Vehari (30.0452° N, 72.3489° E) altitude 140 m. The selected orchards were uniform in age, vigor and plant geometry and selected plants were tagged to record data. Fruit bearing habit, quantification of flushes and harvesting were recorded in the selected orchards. Fruit grades prices during on- & off- years were estimated by conducting survey designed of domestic fruit markets. Fruit availability for export was analyzed through Kinnow processors and exporters survey. Similarly incomes from orchards during alternate bearings were calculated by conducting survey of three districts farmers. Experiment was laid out under Randomized Complete Block Design (RCBD) with three replications. Data regarding parameters was compared by using LSD test with 5% significance level.

## Results and Discussions

Data analysis showed significant economic impact on citrus (Kinnow mandarin) during on-year and off-year, which was explained and discussed under.

### Fruit bearing habit

Among different bearing habit, maximum trees in heavy fruit bearing during on-year were noticed in district Vehari (30%) followed by TTS (25%) and minimum in Sargodha (10%) while during off-year maximum heavy bearing trees were seen in Sargodha (15%) followed by TTS (10%) and minimum in Vehari (8%). Medium bearing during on- & off-years were recorded maximum in Sargodha (70 and 55%) followed by TTS (60 and 50%) and minimum was observed in Vehari during both bearing habit (55 and 45%) respectively. As far as low bearing habit during on-year, maximum trees were seen in Sargodha (20%) and minimum in TTS and Vehari (15% each) while during off-year, low bearing trees was recorded maximum in Vehari (47%) followed by TTS (40%) and minimum in Sargodha (30%) as shown in Figure 1.

Alternate bearing may occur to whole block of orchard or it may be restricted to individual plant or within branches of a plant [19] and in citrus mandarin cultivars are mostly affected by it [11]. Due to late harvesting and high temperature in spring flush more alternate bearing was recorded in districts Vehari and TTS than Sargodha. Fruits of these districts were sold in domestic markets and harvested late which resulted more alternate bearing while in Sargodha due to timely harvesting in January-February, more evenness in crop bearing habit was seen. In citrus, lack of flowering followed by heavy on-year crop [25] and more heavy bearing plants were observed in Vehari and TTS than Sargodha during on-year while uniformity in medium bearing were seen in Sargodha during both on- & off-years. In Vehari and TTS harvesting during on-year was late and affected next year crop as it reduced return bloom [26]. In Sargodha, due to more established processing units for Kinnow fruit export, timely harvesting was done which increased floral shoot number in spring flush and resultantly vegetative shoots decreased [27]. In Vehari and TTS, late harvesting during on-year has affected flowering positions and led to more biennial bearing [19].

### Flush quantification

Three different flushes viz; spring, summer and fall were quantified in three different districts of Punjab during on- & off-year bearing habit, which possessed significant statistical difference as shown in Figure 2. In general, maximum vegetative flush was observed in spring (50-62%) followed by summer (26-35%) and minimum in fall (10-15%) in both bearing habits. In case of spring flush, maximum vegetative growth was seen in district Sargodha (60 and 62%) followed by Vehari (56 and 60%) and minimum in TTS (50 and 56%) during on-year and off-year respectively. During on- & off-years in summer, flush was maximum in district TTS (35 and 30%) followed by Vehari (32 and 28%) and minimum in Sargodha (30 and 26%) respectively. While in fall during on-year and off-year, maximum vegetative growth was recorded in TTS (15 and 14%) followed by Vehari (13 and 12%) and minimum in Sargodha (10 and 12%) respectively and statistically slight differences were observed regarding vegetative growth in all three districts of Punjab during on- & off-year crop.

In citrus (Kinnow mandarin) spring flush is higher than summer and fall flushes [28]. In all three districts during both on and off crop bearing period spring flush vegetative growth recorded higher than summer and fall flushes. Summer and fall flushes vegetative growth was less than spring flush due to hard environment in summer and presence of fruit on the tree [29].

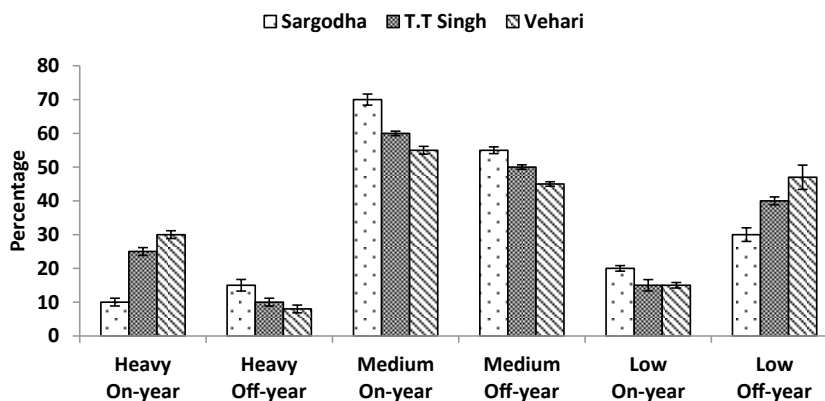


Figure 1: Fruit bearing habit of plant during On-year and Off-year.

Earlier harvesting and mild temperature in spring maximum growth of spring flush during on- & off-years were recorded in Sargodha than TTS and Vehari. In TTS and Vehari, more summer flush recorded during both bearing habits due earlier fruit cell division and development by fulfilling heat units/growing degree days [30] while in Sargodha fruit growth and development goes up to August resulting in less vegetative growth in summer flush. In fruit trees, most of photo-assimilates streamlined towards fruit growth and development [31] resulting in less growth in summer and fall flushes.

As far as fall vegetative flush during biennial bearing period, it remained non-significant in all three districts and remained less than spring and summer flushes. Source-sink relationship of carbohydrate determines trees vegetative and reproductive growth [32,33] and during on-year fruit bearing, more sink developed in fruit and less vegetative flush recorded in all three districts in spring. Similarly, during off-year, less sink developed in fruits and more carbohydrates move towards vegetative growth and more spring flush recorded in all three districts. As spring flush vegetative growth was less during on-year, so summer flush growth was also relatively higher as compared to off-year where spring is high while fall flush during both bearing habits remained same. The results are inconformity with evidence that developing fruits compete for photoassimilates [34].

### Fruit harvesting percentage

Fruits harvesting percentage during on- & off-years were observed

in three different districts of Punjab, presented in Figure 3. At the end of January during on- & off-year bearing, maximum fruit harvesting percentage were recorded in Sargodha (50 and 55%) followed by TTS and Vehari (25 and 40% each). Up till 15<sup>th</sup> February during on-year and off-year, maximum harvesting was done in Sargodha (60 and 70%) followed by Vehari (50 and 63%) and minimum in TTS (45 and 65%) respectively. Maximum harvesting at 1<sup>st</sup> March was observed during on- & off-year in Sargodha (85 and 90%) followed by Vehari (70 and 78%) and minimum in TTS (65 and 80%) respectively. At 15<sup>th</sup> March during on-year and off-year, maximum harvesting was done in Sargodha (98 and 100%), followed by Vehari (93 and 97%) and minimum in TTS (92 and 96%) respectively.

Delayed harvesting in avocado reduced yield and initiated alternate bearing [35] and during both on- & off-year bearing fruit of Kinnow in districts Vehari and TTS, harvestings were done late and more alternate bearing seen as compared to Sargodha where timely harvesting reduced its effects. Fruit bearing affects plant metabolic processes involving coenzymes, sugars and amino acids [36] and late harvesting accelerated it and affected next season crop. Late harvesting in both Vehari and TTS during heavy bearing crop resulted in low crop in next year and timely harvesting in Sargodha has reduced effect of alternate bearing. In Sargodha, well-established processing units for export have positive effects on timely picking of ripened fruits while in rest of two districts fruits harvesting depend on local markets and during on-year bearing period, more gluts were seen in markets and low price has forced to

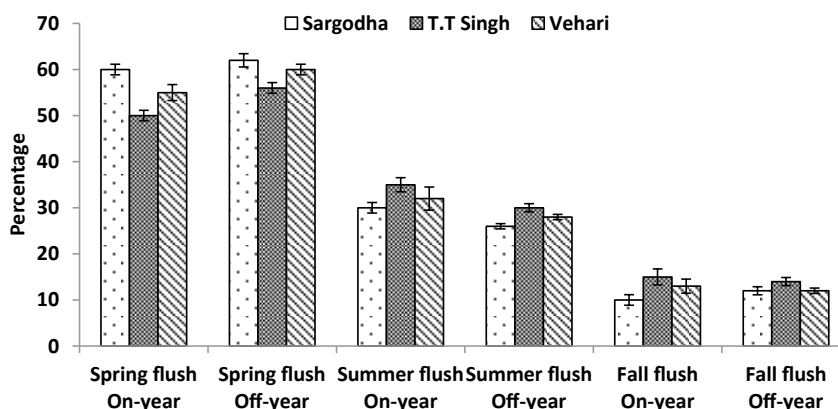


Figure 2: Quantification of vegetative flushes during On-year and Off-year.

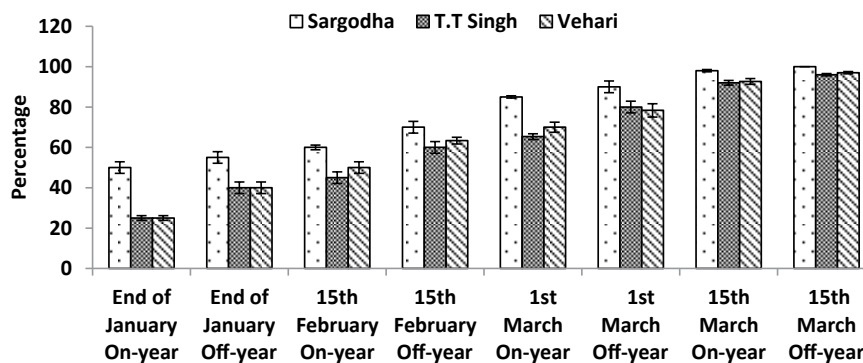


Figure 3: Orchard harvesting percentage during On-year and Off-year.

delay harvesting until reasonable responses from markets. At first day of March, 98 percent harvesting was completed in Sargodha while TTS and Vehari remained behind in harvesting and more trend of biennial bearing were seen.

### Fruit grade price

Data regarding fruit grade price during on-year and off-year showed significant difference among different months shown in Figure 4. In month of January, maximum A grade price during on-& off-year was recorded (517 and 567) followed by B grade (217 and 257) and minimum of C grade (107 and 123) respectively. During on-year and off-year in month February, maximum price was observed of A grade (633 and 667) followed by B grade (283 and 293) and minimum of C grade (137 and 147) respectively. Similarly, in month March during on-& off-year, maximum rate was recorded of A grade (733 and 783) followed by B grade (317 and 383) and minimum was seen of C grade (153 and 167) respectively.

Price of citrus fruit fluctuates from year to year and within a year [20] and during on-year heavy bearing resulting low fruit quality with smaller size and more gluts in markets. During heavy bearing season, all citrus grades prices during months of January, February and March remained low than off-year crop. In off-year bearing, fruits quality and size were observed well than on-year and fewer gluts in market had fetched more prices of all fruit grades. Price of A grade fruit during

on-& off-year remained low in January and February than March while price of B grade during on-year remained same with slight difference in all harvesting months. During off-year, B-grade price were recorded higher in March than February and January (Anonymous, 2014) but no significant difference was observed in C grade price during biennial bearing in all three months (PHDEC, 2017) which justified present study results.

### Fruit available for export

Alternate bearing has put substantial impact on fruit availability for export which is presented in Figure 5.

During on-year and off-year fruit bearing habit, maximum fruit availability for export was recorded in month December (100% each), followed by January (80 and 60%), February (50 and 35%) and minimum was seen in March (15 and 10%) respectively.

Export fruit grading and processing units are located in only district Sargodha where earlier picking of fruit has minimized the extent of biennial bearing but fruit availability for export is indirectly affected by domestic markets rate. During on-& off-year in month December fruit availability was seen 100 percent. In January, fruit availability during off-year was reduced to 60 percent as compared with on-year 80 percent due to high price in domestic markets. High price and less quality fruits during off- year in February have further widened difference of fruit availability for export than on-year in same month.

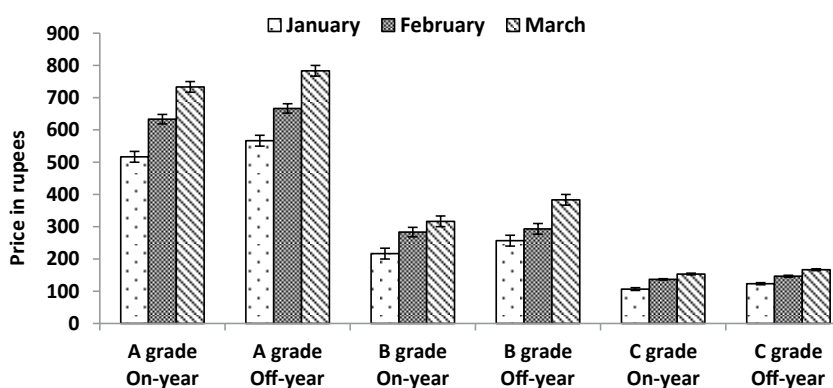


Figure 4: Fruit grades price during On-year and Off-year.

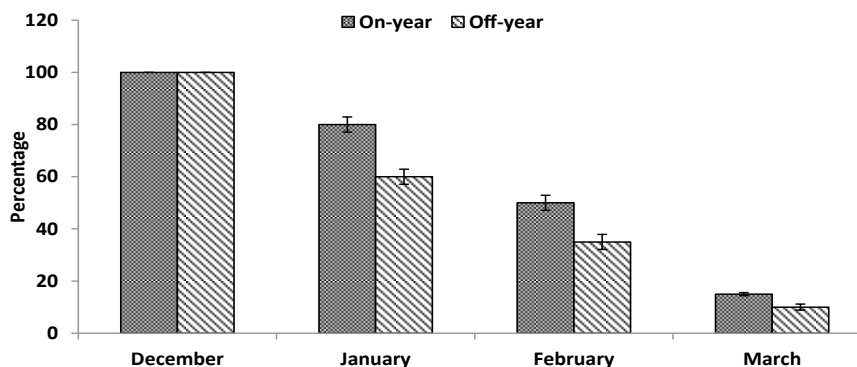


Figure 5: Percentage of fruit available for export during On-year and Off-year.



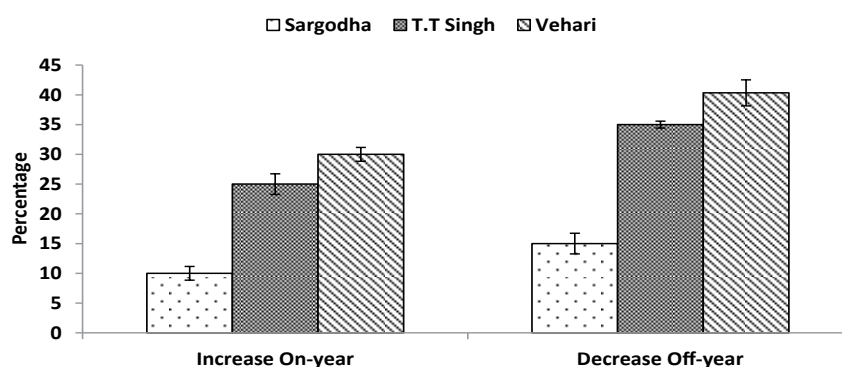


Figure 6: Income of farmers during On-year and Off-year.

Slight difference was observed in March during biennial bearing period of fruit availability for export. Fruits were available for export during on- & off-years but preference of middlemen during off-year were in local markets where price of good quality was seen more than rate fixed by processing units in months of February and March [5]. During off-year, fruits were costlier at farm-gate and more expenses were recorded for export as compared to on-year. In addition, 90 percent Kinnow orchards were sold to middlemen/contractors [37] and their presences were seen to where more rate come and during off-year and domestic markets rate were recorded higher than exporting factories [38] that indicated that fruit availability for export were affected by biennial bearing.

### Income of farmers

Income from orchards during on- & off-year was observed in three districts and presented in Figure 6. Maximum income increased was observed in District Vehari (30%) followed by TTS (25%) and minimum in Sargodha (10%) during on-year, while decrease in income during off-year was recorded maximum in Vehari (40%) followed by TTS (35%) and Sargodha (15%).

The extent of biennial bearings were less seen in Sargodha than other two districts and farmers income from citrus orchard differences were recorded 15 percent less in off-year than on-year. In addition, more good quality fruits were seen during off-year in Sargodha and high prices of Kinnow fruit in domestic markets were observed. Due to less extent of alternate bearing in Sargodha, fruit supply and price fluctuation were not significantly differed which ultimately not affected farmers income in both seasons. While in TTS and Vehari, the extent of biennial bearings were observed higher and farmers' income differences during on- & off-year were become widened. In off-year, 35 and 40 percent prices of orchards due to low bearing were less recorded in TTS and Vehari districts respectively. Middlemen profit margins were recorded higher in Kinnow fruit [39] and more extent were observed during off-year in district Vehari and TTS and farmers income decreased significantly in biennial bearing.

### Conclusion

An economic analysis of on-year and off-year citrus (Kinnow mandarin) was performed to assess impact of alternate bearing on citrus industry in Pakistan. The study was conducted in three main citrus groves and maximum heavy bearing trees during on-year were recorded in districts Vehari and TTS while less was seen in Sargodha.

Similarly during off-year, maximum low bearing plants were seen in Vehari and TTS while fruit bearing evenness was observed in Sargodha. Fruit bearing habits affected vegetative flushes quantification and quality and grades of fruits. Due to domestic market dependence, harvesting of fruit was seen late during on- & off-years in TTS and Vehari districts while exporting of Kinnow fruits has resulted timely harvesting in Sargodha. In Sargodha, farmers' incomes were not affected due to alternate bearing but domestic markets fluctuation during biennial bearing has adversely affected net return from orchards in Vehari and TTS. The present research finding will be useful in future to minimize alternate bearing by timely harvesting during on-year and planning future mechanism for supply chain in domestic market.

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