Geospatial Analysis of Citrus Orchard Soil, Leaf Nutrient Concentration and Relationship with High-Resolution Drone Imagery and Yield

By

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Remote Sensing and GIS

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To

My Sweet & Loving Family

Thanks for their love, care, and motivation since the start of my studies, and to all those who encouraged me and prayed for me for the completion of this thesis.

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I, **Zaheer Ahmad Gondal** declare that this thesis and the work presented in it are my own and have been generated by me as the result of my own original research.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
Wd	soil wetness/ droughtiness
Ca	calcium
Cm	centimeter
Mm	Millimeter
Km^2	square kilometer
Mg	Milligram
Ml	Milliliter
S	sand
C	clay
Ls	loamy sand
Sc	sandy clay
Zc	silty clay
Ol	organic loam
Sl	sandy loam
Szl	sandy silt loam
F	fine (more than 66% of the sand < 0.2mm)
C	coarse (more than 33% of the sand > 0.6mm)
M	Medium (< 66% fine sand and < 33% coarse sand)
Co_2	carbon dioxide
Gps	Global positioning system
Idw	inverse distance weighted
K	potassium
Zn	zinc
Ms	Microsoft
N	North
Na	Sodium
Ph	power of hydrogen ions
R^2	coefficient of correlation
Rmse	Root mean square error
Sd	standard deviation
Uc	union council
Utm	universal transverse Mercator projection
N	Nitrogen
W	water content or moisture content
R-squared (r^2)	coefficient of determination
Mlr	Multiple linear regression
Sa	Spatial auto correlation
Ols	Ordinary least squares
Gwr	Geographically weighted regression
Wb	World bank
adb	Asian development bank
Un	United nations

Abstract

Degradation of citrus orchards production in the region may be caused by several factors including lower soil fertility, high salinity, and diseases. This study will identify the major issues that may affect the quantity and Quality of Citrus in the Sargodha district. Conventional techniques, including laboratory analysis used for soil & leaf physiochemical attributes estimation is time-consuming and costly. Modern scientific era demands a more effective methodology to estimate soil &leaf physiochemical attributes. Precision Agriculture, Remote Sensing & G.I.S. proved to be an effective remedy for this problem. Scientists worldwide are using Remote Sensing data with a variety of conventional and non-conventional methods to model and predict the different issues of kinnow crop. Classical Statistics have been widely used in research to model soil properties using remote sensing data. Growing G.I.S. knowledge has brought spatial regression modeling techniques to model and predict the citrus issues in any area. UAV monitoring and soil & leaf testing have brought further changes and addition to the subject a step ahead. The subject is in the exploratory phase and researchers are coming up with new methodologies and techniques to solve the citrus-related issue. This scientific research adds innovation to the subject by comparing various remote sensing techniques and two famous sensors Landsat-8 & UAV and the ground data for the mentioned purpose. This research focused on investigating soil &leaf chemical properties of the citrus crop using G.I.S. and Remote Sensing. To explore soil chemical properties, Classical statistics, Geostatistics and Spatial Interpolation (S.I.) were analyzed in this review. Inverse Distance Weighting (I.D.W.), Kriging Interpolation, Geospatial analysis were used to model and predict soil & leaf chemical properties of citrus crops. Soil Organic Matter (O.M.), pH, Nitrogen, Potassium and Phosphorus were tested with acceptable accuracy using variety of scientific techniques in the laboratory under a controlled atmosphere. Leaf mineral content also tested in the laboratory. UAV data and ground data were compared and evaluated for predicting the citrus' soil & leaf chemical properties (Kinnow). Using classical statistics, M.L.R. for spatial data may not be realistic since it does not consider spatial variability, limitations in classical statistical models were successfully overcome using Geostatistics & spatial regression. UAV data and better resolution were used to identify nutrient deficiency both in the leaf and soil of the study area. UAV monitoring along with soil & leaf testing of the area gave better results. For SI, no technique was found to be best; rather S.I. accuracy depends on data spread and magnitude.

Chapter 1

Introduction

Pakistan has been honored by a broader scope of many climatic variations and geographical circumstances by the Allah Almighty which is generally favorable to the development of an assortment of organic product trees. As per an assessment current creation of the natural products on the planet is 33519.325 million tons under a space of 4874.78 (000) ha. It is generally exported everywhere globally, including Brazil, U.S.A., Iran, Italy, Pakistan, China, Spain, India, and Pakistan. By and by, the yearly production of Citrus in Pakistan is round 2.2 million tons on a patch of 194000 ha and it contributes almost 25 percent in G.D.P. to 40percent work open doors in Pakistan. kinnow has a place with Rutaceae family and it tends to be created at business scale in a wide scope of tropical areas, sub-heat areas and in excess humidity areas. It has many different forms and shapes like mandarins, limes, oranges, grapefruit and lemons. Along all of these, 'citrus' has a place with mandarin gathering and it is a noticeable kinnow cultivar in Pakistan. Significant business sectors of Pakistani 'Citrus' for trades are Saudi Arabia, middle eastern and Arab countries. Province Punjab is the significant grower of kinnow in Pakistan, which Contributes a major portion around 95% of all out citrus production, out of which major part almost 76 percent is 'Kinnow'. 'Kinnow' mandarin being a major citrus producer in Pakistan, contributes 71 percent of absolute kinnow creation.

1.1 Importance of study

Kinnow is a vital natural product due to its satisfying taste and high nutritious worth. In this manner, it is liked by individuals because of its elite taste and flavor. New and handled natural products are the acceptable wellspring of nutrients, dietary fiber, and minerals. The dietary benefit of Citrus is high. It is a rich wellspring of ascorbic corrosive and gives fundamental mineral supplements. It gives an equilibrium and tangible way of life to forestall various kinds of heart infections and diseases like lungs, liver, skin, and numerous other birth surrenders. Because of the absence of land assets and high costs on plantation planting, the board tasks and gathering, a large portion of the citrus cultivators favor those strategies to use their assets effectively. In a high thickness manor, little citrus trees can be filled so they can get the most extreme daylight to improve the high return and organic product quality in a bit of region. High thickness planting in Citrus is another progression to decrease consumption and increment their productivity. In high thickness manor number of plants increments thus, yield and pay is more, when contrasted with generally separated ranch. Higher spaces between plants improve the vegetative growth just as yield of 'citruses. Branch cutting in highly dense plants is vital for appropriate sunlight entrance. That is needed after appropriate stretches to keep up the shade volume and state of the trees. Daylight is vital for the high return and better nature of the organic citrus product. Hence, appropriate fixing (expulsion of apical part) and supporting (evacuation of horizontal) in citrus forests improve the most incredible light entrance, which upgrades organic product yield and nature. Because of inappropriate pruning, less light and helpless air circulation, second rate nature of fruit are delivered. There are numerous elements, for example, over-the-top leaf drop, helpless natural product setting, and natural product drop at different formative phases of the organic product, which seriously impact the creation of Citrus. Besides these, legitimate supplement the board likewise assumes a significant part of good quality citrus organic products. Numerous components, for example, Different soil texture, nourishing condition, kind of roots and plants physical health, impact the take-up of supplements from organic product plants. Most of Pakistan's soil profile has been insufficient in a few plant supplements that diminish both tree wellbeing, creation, quantity, and Quality. (P.N.K.) being macronutrients assumes a significant part in the natural product yield and nature of 'Clementine' mandarin. N is generally significant among every full-scale supplement, and it is fundamental by the plants for their vegetative and conceptive development.

It is needed by organic product trees for some natural interaction like development, cell division, photosynthesis, and breath. Insufficiency of N initially shows up on more established leaves; green shading transforms into light yellow. In this manner, an adequate measure of N application may expand the vegetative tree development. P is second most significant supplement component fundamentally needed by humans, creatures just as vegetation. Plants required P in modest quantity only second to the N. It assumes an indispensable part in fats, proteins, and starches digestion. It goes about as go-between to give energy to metabolic cycles i.e., maturation and breath. It builds the opposition of plant against infections and furthermore expands the nature of harvest. It performs vital capacities in plant like enzymatic exercises, photosynthesis, sugar digestion and portability. P is likewise significant for development and advancement of blossoms and organic products. Inadequacy of P results in deform course leaves, low Quality of organic products with thick strip and low acidic juice contents. K is additionally a significant full-scale supplement needed in bigger amounts as it improves organic product quality by upgrading organic product tone, size, and squeeze flavor. It is associated with different physiological capacities, such as typical cell division and development, protein combination, and the arrangement of sugars and starch. It is improving the natural product size, yield, nutrient C substance and natural product quality.

Moreover, K controls the stomatal developments to manage the stock of CO_2 and keeps up electro nonpartisanship in cells of Citrus. Henceforth, insufficient inventory of K may result decrease in yield and nature of organic products. Consequently, an appropriate N, P and K stock is fundamental for maximum return with prevalent natural product quality, particularly for 'citrus'.

There is a need to foster a legitimate sustenance plan for 'Citrus' when developed under high closer dense estate. Prior, detailed that N@ 850g per tree with severe pruning improved the vegetative development with upgraded organic product setting and natural product quality. It has been additionally detailed that 250-500g P per tree with light to medium pruning improved the vegetative development, conceptive conduct just as upgraded nature of 'Kinnow' mandarin. Also, research detailed that the use of 850 g K for each 'Kinnow' tree with extreme pruning has been recorded to improve development, growth and organic product quality under closer dense plantations. Additionally, data about the reasonable degree of join utilization of Nitrogen, Phosphorus, Potassium as the compound will be utilized for further examinations. The result of that particular examination was to research the impact of various degrees of Nitrogen, Phosphorus, Potassium compound manure on the development, usefulness, and nature of 'Kinnow' developed under low spacing's with various cutting forces.

1.2 Literature review

Kinnow is a significant organic product crop having a place with the family Rutaceae. That has already been accounted for that Citrus is being filled in almost 52 nations all throughout whole planet. As indicated by region and creation, citrus positions first among all of the tree organic products in our country. As of now, in the country creation and nature of kinnow is still less, when appeared differently in relation to the made countries in spite of the fact that it has ideal soil and environmental circumstances. In this manner, there is a need to expand natural product quality and yield with restricted assets to satisfy the energy necessities of individuals (Nawaze et al., 2014). For well growth of citrus trees, major sixteen supplements are necessary that are additionally classified as full scale and miniature supplements as indicated by their requirement. Nine components out of these major sixteen are needed in a bigger amount and named as large scale while others are needed in little amount and known as micronutrients. Notwithstanding, mineral supplements are acquired from soil while water and carbon dioxide give Carbon, Hydrogen & Oxygen to the plants. Main issues in kinnow growth in Pakistan are inappropriate structure, poor quality, pre full grown fall and helpless shading advancement. These are the major issues in that dirt which are inadequate in basically desired supplements (Ebrahem et al., 2010). Untimely natural product drop, shade of foods grown from the ground are straight forwardly associated with the chemicals that are upset by the insufficiency of fundamental supplements. Use of chemicals and supplements at untimely stage decrease the organic product drop rate in Citrus (Ashraf et al., 2012).

High thickness manor is extremely mainstream for foundation of new orc Harding the created nations. Presently a day's citrus producers incline toward high thickness manor in citrus forests. It has been empowered by different factors like deficiency of land, lack of water, absence of talented work, significant expenses of fuel, apparatus and work primarily contributed to high planting thickness. The principal benefits of high thickness plants are more accommodation in plant insurance, tree wellbeing, simple consideration and gather. In addition, in citrus forests, dividing becomes a significant thought since that helps in faster creation and exceptional yields in early long stretches of planting. 'Kinnow' trees filled in maximum thickness manor, become taller than typical example of development where they vie for all the lighter, so tree get more stature. In high extensive dispersing all the lighter infiltration, huge overhang region and more quickly developing parallel branches improve the size and nature of organic product. Henceforth, for early creation and more returns moderate plants separating alongside appropriate overhang the executives are important. Though, in closer thickness plants customary cutting is necessary (Nawaz et al., 2014).

Cutting is the act of specifically eliminating plant parts (branches, buds, spent blossoms, and so forth) to control the plant for green and scene purposes. Pruning (cutting) is the prudent expulsion of fresh or dry plant portion or branches from standing tree for the betterment of design and wellbeing. It could be the expulsion of sickness or bug contaminated segment, undesirable tree parts or dry plant portion. It assists with keeping up the open overhang and great design to forestall the breeze harm. Cutting is generally completed in the late winter season or late before the rise of new leaves and plant development. Preparing is additionally vital in developing long periods of tree for solid tree structure (Bicon and Bavington, 1980). Citrus's legitimate pruning ought to be proceeded at explicit stretches in high thickness planting to keep up the ideal tree canopy and size with least shade loss as serious pruning reduces the fruiting wood (Zaki, 2013). Consequently, pruning in high thickness is extremely fundamental to keep up the canopy of tree where concealing of lower covering diminished the yield and nature of the organic product (Cirry, 1983).

Fixing along with supporting is done in grapefruit when planted in close thickness to upgrade the social and gathering tasks (Tuckar and Whiton, 1980). cutting is a significant farming practice in high thickness manor of kinnow for legitimate sunlight entrance and shelter the executives. Ill-advised pruning on ill-advised span lessens the tree development just as creation of fruits (Zeki, 2011).

Pruning is the main farming practice in natural product trees. It could be light, medium, or serious: It additionally enjoys a few benefits and drawbacks. Unnecessary and ill-advised pruning may cause loss of fruiting buds, defer organic product development, decrease natural product quality, and improve the development of water sprouts. Extreme cutting improves vegetative development and decreases regenerative development, while little pruning might be done whenever in the year with no impact on productivity (Bavington, 1982).

Cutting is a better way to enhance 'Balady' trees (Salem et al., 2010a). When supporting of 'Valencia' oranges is made after a month-to-month span from Sep to April, it delivers a greater count of conceptive flushes (Bacion and Bavington, 1980). Extreme cutting improves the canopy of new guava shoots as contrasted and medium, squeezing and control (Shabaan and Haseb, 2011). cutting is useful to upgrade the blooming shoots in organic product trees. In addition, in corrosive lime trees a greater blossom were noticed, when plants were reasonably cut (Iingle et al., 2003). Fixing of grapefruit at the stature of 3m and supporting at4m width improved the extent of natural product under and close to the lower part of covering (Fuuick, 1981). Weighty pruning expanded the yield as far as natural product per shoot and greatest weight and size of organic product; while, less in numbers and substandard in nature of natural product were seen if there should arise an occurrence of weak and non-cut trees (Ahmed et al., 2008). Greatest growth was gotten in 'Valencia' when evaded at 20inch stature as contrast with avoiding the plants at tallness of 38 inch and normal yield of these medicines was more than control or where no evading medication was applied (Witney et al., 2005). Suitable cutting enhances the natural product set in 'Haden' mango trees (Gill et al., 1999). Similarly, cutting likewise upgraded the organic product growth in 'Dashehari' mango trees (Mohain et al., 2003). In season of winter pruning of peach plants improved the blossoms buds, when contrasted with summer cutting (Hossain et al., 2007). Small cutting in 'July Elberta' peach essentially upgraded the organic product set than moderate and serious pruning (Shairma and Chahuan, 1996). Likewise, little cutting in 'Paluma' guava also expanded each branch's number of organic products (Serano et al., 2010). Pruning essentially improves the outside just as inner natural product quality attributes. Ahmad et al. (2008) detailed that weighty pruning of 'Kinnow' essentially improved the natural product tone, natural product size, natural product weight, juice substance with lower strip rate. Improvement in natural product quantity and growth was essentially seen in fixing of 'Murcott' trees, in contrast with those not topped (Stover et al., 2005). In 'Valencia' no steady impact of supporting on natural product size was accounted for (Bavington and Bacion, 1980). Serious pyramidal shelter cutting of 31 years of age 'Shamouti' orange trees diminished organic product weight fundamentally before long (Moreshet et al., 1999). Utilization of compost alongside medium and extreme pruning in apple gave the higher natural product weight and yield (Ahmad and Razi, 2007). Essentially, expanding the seriousness of pruning from less to extreme cutting in red apple 'Fuji' decreased the harvest load; while enhance the weight and size of natural product (Bound and Summers, 2003). Summer pruning in peach expanded the light infiltration and upgraded the natural product quality (Room and Ferre, 1983). The application of cutting treatment in mango enhanced the natural product quantity, growth, and Quality, particularly expanding the T.S.S. (Yeshitala et al., 2007). Cutting altogether enhanced the growth and size of organic guava product however with no change in ascorbic corrosive substance (Salman et al., 2007). In pear natural product pruning power alongside mulching treatment improved the T.S.S. rate when contrasted with control (Moniruzzama et al., 2009). Intensely pruned trees of peach 'July Elberta', T.S.S., complete sugars and solvent protein content were essentially high than in medium and little pruned trees (Sherma and Chahuan,1998).

Citrus is exceptionally reliant upon the dietary status of the dirt and show extensive reaction to the compost applied. The application of compound composts got generously great outcomes because of the explanation that insufficiency of any supplement decreases yield and organic product quality. N is generally significant among every one of the mineral supplements that may influence the Quality furthermore, creation of organic products (Wange et al., 2008). Nitrogen is a generally indispensable nutrient required for the appropriate advancement of any tree. It is pondered as a huge portion of various metabolic and fundamental segments in plants. It is a fundamental piece of chlorophyll that uses daylight to change water and carbon dioxide to deliver sugars (Abas and Faries, 2010). Nitrogen has a basic influence in the arrangement of energy move intensifies like ATP, which use and save the energy created by the metabolic responses during a breath and relate with various biochemical capacity in the phone like leave creation, bloom commencement, development, natural product quality and natural product set (Agfct, 2004).To be a critical part of the relative multitude of amino acids, it controls practically every one of the body exercises by developing catalysts and protein (Zakri and Obriza, 2005). In kinnow, N is key for good development and organic product quality. It lessens the expense of creation by expanding the natural product creation and improves the nature of organic product (Must and Williamsoon, 1996). It has been stated by Dou et al. (1999) that an appropriate plan for the substitution of eliminated supplements during development ought to be embraced for compost application adequacy, natural deposits and yearly development. Developed soils are weak in natural material in Pakistan, calcareous and soluble in nature with semi-parched and bone-dry climates. In this manner, the most significant factor for the usefulness of the harvests is supplements lacks (Rashed and Rayan, 2006). Welch and Graham (2006) recommended that N lack in plant is fundamental globally in view of their generous part in human sustenance. Various morphological and physiological manifestations on leaves, natural products, and shoots might be apparent brought about by the lack of the N in the dirt during the development (Ioanis et al., 2006). Hindered appearance, axle, and flimsy, stem with light green shading leaves are qualities of N inadequacy (Braady and Weeil, 1998). As per Agfct (2004), leaves convert pale with trademark little size in spring. One of the keys restricting components for bad Quality and yield is the inadequacy of N (Mrschner, 1996). The essential reason for N inadequacy is the low accessibility of N in the dirt, which might be a result of different elements. Draining is caused because of weighty rainfalls or over-water systems with exceptionally permeable soils. Waterlogging state of soils can cause N misfortunes through denitrification that can cause an impermanent Nitrogen inadequacy. More fragile and more established trees that are insufficient in N might be improved with valuable Nitrogen compost in continuous applications (Zakri and Obriza, 2006).

Numerous biotic (cultivar, rootstock, bug and illness the board and so forth) and different abiotic (environment, soil, sustenance, water system the executives and so on) factors influence the efficiency of Citrus (Iglesaas et al., 2009). An appropriate stockpile of citrus plant supplements is greatly significant among above-referenced components in the guideline of tree development and organic products. Enough inventory of supplements for citrus trees is needed for vegetative and regenerative development just as for great quality natural products. Nitrogen is fundamental for ideal development and great creation (Aliva et al., 2008a).

Generally, full-scale supplements, for example, Nitrogen, are applied to the citrus plants through the soil as they are needed in larger amounts. Albeit, supplement applications to soil are exposed to various destinies i.e., draining, spillover and obsession into structures that are inaccessible to the plants (Albrago, 1998). It is clear that foliar application is not proposed to supplant soil use of macronutrient treatment. Additionally, it is believed that foliar use of any nutrient is costlier because a few applications are needed to fulfill plant needs and keep up high returns (Zekri and Obreza, 2005). Generally, plants retained supplements through roots; thusly, manures are applied into the dirt (Mengel, 2004). While to upgrade the usefulness, soil application may give enough supplements (Dinnes et al., 2004).

Among every one of the supplements, N is quite possibly the most significant for citrus development that is needed in a bigger amount than different supplements to improve the development and advancement of the plant (Thompason et al., 2004). Amino acids are the major constituents of Nitrogen which play a significant role in the digestion and development of the citrus plant. Besides, higher measure of N is useful to expand the vegetative development of Citrus (Lue et al., 2004). In little plants of oranges, constructive outcomes of Nitrogen has been accounted for on development boundaries (Mauist and Willamson, 1996). Use of Nitrogen compost altogether influenced the tree size, plant tallness and its covering volume

(Manino et al., 2005). Ideal plant development happens with the use of Nitrogen manure. Betterment in everyday wellbeing, life just as in yield of the plant is accounted for with utilization of N (Ale et al., 1995). It has been accounted for that Nitrogen has an extraordinary impact on the development and advancement of plants, influencing the development of leaves, branches, and natural products (Ali and Lovatt, 1996). Absolute development of 'Valencia' oranges plants was discovered to be reliant upon Nitrogen levels (Smiith and Reuthar 1956). Use of Nitrogen for youthful citrus plants favors the vegetative development and it diminishes the blossom bud enlistment (Manino et al., 2005). Utilizations of various convergences of urea alongside GA3 shower fundamentally improved the development of mango trees (Rajpoot and Singha, 1991). Development in vegetative cover, yield, wholesome status, and natural product quality in 'MitGhamr' peaches was upgraded by use of urea with sulfur covering (Kandeel et al., 2012). Low N level in leaves advances exorbitant blossoming, all things considered the organic product set and yield is poor. Subsequently, keeping the leaf N rates in ideal reach produces a normal number of blossoms with the most extreme natural product set. Blossoms delivered at a plant are associated with N status in tissues on the grounds that at the hour of bloom improvement N is moved from leaf tissues to blossoms (Smith and Reuther, 1956). It has been accounted for that utilization of N compost prior to blossoming diminished bloom drop. The low Nitrogen levels in tree during blossoming time and natural product setting may prompt more modest yield paying little mind to N levels as ideal during staying fruiting period (Jons and Embliton, 1969). Urea application assisted with improving blossom inception and at last expanded the blooming power of 'Clementine' mandarins (El-Otmana et al., 2004). Albrig (1998) detailed that there was a huge expansion in blooming of 'Valencia' oranges with foliar urea shower. Utilization of urea 6 two months earlier sprouting improved blossoming in 'Shmouti' oranges (Lovatt, 2001). As indicated by Rajput and Singh (1991) best return in mango plants was recorded with 4% urea splash. Grapevines needs more Nitrogen particularly at blooming period (Ekbac et al., 2012). While low Nitrogen in papaya plants have been found to boost male blossoms (Arkl and Nakason, 1988). Mineral sustenance effect on the cycle of organic product setting is notable. N preparation expands the organic product set in plants, while P application builds bud burst. Like the most requesting supplement by plants, N has been accounted for to improve the natural product set in Citrus (Salem et al., 2007). Blossoming force and organic product set are straightforwardly identified with leaf Nitrogen substance (Arura et al., 2000). Verdant inflorescence, particularly with maximum Nitrogen applications, set a heavy natural product in 'Valencia Late' orange trees; while, in trees with Nitrogen lack their regenerative organs were dropped out for the most part of nowhere and they were found useless (Lanz, 1968). Nitrogen application has been accounted for to upgrade natural product set in citrus trees (Rabi, 1996). N fertigation was found dependable to amplify the natural product set rate in 'Shamouti' oranges plants (Dassburg et al., 1986). Natural product set and the quantity of natural product per tree was improved dynamically because of expansion in number of applied Nitrogen levels in 'Balady' mandarin (Koullka et al., 2002). Researcher revealed a tad contrast in organic product setting of Citrus, by providing ammonium sulfate, ca ammonium nitrate and urea as Nitrogen source. Diverse Nitrogen fustigation levels demonstrated that with expanding Nitrogen level there was a progressive augmentation in level of beginning just as definite natural product set and natural products per tree were likewise expanded. N insufficiency during sprouting time may cause an excessive amount of abscission bringing about lower natural product set (Chandler, 1959). Like citrus organic products, it has been likewise detailed that organic product setting of cherries and apricots could be advanced by appropriate Nitrogen fertilization (Whity, 1969).

Organic product drop is normal interaction, which is a characteristic burden the executives of the plant that maintains a strategic distance from abundance seepage of organic product saves from the tree. Environment, nourishment, and well-being of plants are fundamental drivers that might be answerable for organic product drop (Rasko et al., 2008). There are basic 3 kinds of organic product fall taken in the writing in various organic product crops like Citrus as soon after the natural product set, June fall and third one is pre collect natural product fall (Daves and Albrgo, 1996). Appropriate mineral nourishment application has been accounted for to yield great outcomes in maintenance of natural products. Different reports demonstrate that the blend of fruitlet from ovary and fruitlet abscission relies on accessibility of supplements (Gomaz-Cadenus et al., 2002). Inadequate treated organic products rate is liable for the organic product drop during the developing season. Sing and Sing (1975) announced that foliar use of 1 to 3 percent urea, diminished the proportion of organic product fall in 'Kaghzi' lime. Low-level urea diminished the underlying organic product fall just as expanded the creation of different plants (Ali et al., 1995). Use of low biuret urea has been proposed to build yield of foods grown from the ground of attractive sweet oranges (Citrus sinansis L. Osback) (Salem et al., 2009b). Jone and Emblaton (1969) explored the role of different Nitrogen composts on develop 'Washington Navel' oranges and they announced that an extensive expansion in yield with expanding Nitrogen levels. In this way, greatest organic product yield was accounted for with the most noteworthy pace of N applied during fall and spring in oranges. Yield of the greater part of the orange cultivars was fundamentally influenced by utilizing N through fertigation (Boman et al., 1998). Bravado et al. (1998) revealed that the greatest yield of organic products per ha was acquired in 'Balady' mandarin by utilizing N.P.K. Expanded Nitrogen rates relate to expanded yield of numerous Citrus. Treating the Lemon trees with 700 to 900 g of Nitrogen for every tree came about in most extreme yield than some other Nitrogen level (Kooi et al., 1976). Yield of grapes was influenced by N treatment; the best return of grapes was gotten with the use of 21 kg N for each ha. As per discoveries, grapes yield was altogether improved by Nitrogen application (Tera et al., 2002). Aroora et al. (2004) recommended that blooming power, organic product set, organic product weight and yield are straightforwardly related with leaf Nitrogen content in peach tree. Draki et al. (2006) announced that natural product nature of apples cv. 'Brilliant tasty's fundamentally improved by the Nitrogen application.

Among of three essential macronutrients, Phosphorus has incredible significance which is needed in bigger sums by kinnow plants. In kinnow plantations, it is utilized as a significant piece of any decent sustenance strategy proposed to augment monetary yield and keep a favorable climate. All living things contain Phosphorus, exceptionally youthful parts like blossoms and seeds. It is basically needed for different physiological cycles, i.e., photosynthesis, amalgamation, or different starches, just as energy moves inside the plant (Socanu et al., 2010). Phosphorus helps the trees in move and capacity of power from photosynthesis for seed development, root advancement, cell division and development just as impervious to push. It is additionally needed for take-up and movement of different components (Hamami et al., 2012). It is helpful to increment natural product size, juice rate, yield and titratable sharpness and to diminish skin thickness (Man and Sandu, 1990). Be that as it may, exorbitant P in Citrus lessens natural product quality by upgrading T.S.S./corrosive proportion. The abundance of P may expand the number of green natural products or lessens strip thickness what's more, it may communicate wind scar. In any case, the reaction of kinnow plants to P preparation fluctuates significantly and it is reliant to scion and rootstock blend (Quagioet et al., 2008). Citrus plants are exceptionally supplement requesting which identify great reaction to applied supplements. Tree development with high organic product yield of better Quality can be improved by utilization of mixed manures. Insufficiency or abundance of any supplement can prompt decrease in yield with substandard natural product (Ibrahm et al., 2009; Ashrif et al., 2012). A lot of P ought to be given to the plant for ideal development as its capacities in citrus plants can't be supplanted by some other component. By and large rural yields contain 0.2 to 1.5% of Phosphorus that plants use through roots. When Tree roots take up Phosphorus, these may store or move to different pieces of plant (Whaton et al., 1993). Different substance responses can incorporate it into various natural mixtures, such as D.N.A., sugar phosphates, chemicals, and energy-rich phosphate mixtures (ATP). It's anything but a job in plant photosynthesis, change of starch and sugars, and development of supplements inside the plant just as move of hereditary attributes from one stage to another stage (Obrezaet al., 2010).

Due of dry to the semi-very dry climate of Pakistan the soils are calcareous thusly having weak regular matter. Phosphorus lack may prompt the amazing impacts like decreased leaf development, surface region, and leaves. If Citrus should arise, if Phosphorus content is not precisely almost 0.09 % in leaf, then it shows inadequacy. Regularly, because of lacking P content, the interaction of starches utilization eases back down, even though carbs blend proceeds through photosynthesis. With lacking P plants may foster purple shading leaves in Citrus.

Additionally, P inadequacy may create a setback for development or diminishes organic product quality just as diminishes obstruction against sicknesses. Restricted accessibility of P diminished the creation of flower structures (Srivastava, 2015). Over the top measure of P severely influences citrus development and advancement, particularly organic product quality. Higher P preparation brought down T.S.S. of juice and may cause delay in shading advancement of oranges (Koi, 1990). In light of Phosphorus insufficiency, natural products may have a harsh surface and coarse, thick skin with an empty center. Phosphorus being huge macronutrient required in smaller sum than Nitrogen. Incidentally, it is required in most prominent totals in such areas with the issue of low soil productivity and low Phosphorus availability in soil because of its maximum fixation on soil (Hamami et al., 2012). Phosphorus may react with Al, Ca and earth in soil and may lose its availability and adaptability in the earth. Plants can use around 22 percent of complete Phosphorus applied to them, because of its higher fixation (Chapmn, 1965). Phosphorus and magnesium has comfortable relationship with the objective that Mg goes about as phosphate transporter (Nawz et al., 2014). Moreover, Magnesium is adaptable in plant parts which contain high Phosphorus sums and the tree parts containing higher Phosphorus they may also have more raised degrees of Mg.4.5.6.

1.3 Climatic circumstances

Improvement of kinnow trees may be affected by different factors like varying climatic circumstances, soil the board, tree location, root stock, collection, treatment, water framework bug and irresistible avoidance, etc. P is applied to citrus trees through soil in view of its fame. Foliar dealing with macronutrients can't absolutely displace the soil application. Likewise, foliar shower of macronutrients is seen as more extreme than soil application techniques (Zakri and Obriza, 2015). By and large, plants taken up the water and supplement through their root system henceforth Phosphorus is excessively applied into the earth (Mangel, 2004). From proper soil application sufficient Phosphorus can be given to plants to update their turn of events and convenience (Dineset al., 2004).

Leaf assessment is done to choose feeding status of tree hoping to be the proportion of parts present in leaves at the hour of examining (Bayrs, 1964). It offers information to get an understanding about compound fertilizer and essentials of a plant. Supplement application through and through enhance the leaf mineral substance in 'Feutrells Early' and 'Kinnow' plants (Salem et al., 2007). Healthy application, especially Nitrogen, Phosphorus and Potassium, before the ascent of new advancement improves Citrus's natural item yield and nature (Grenery et al., 1974). Phosphorus is a second huge full-scale supplement that is needed by the plant simply second to the Nitrogen. Phosphorus openness in genuine total may enhance root progression, decline destructive obsession, begin blooming, and increase developing collaboration of the natural item (Socanu et al., 2010).

1.4 Importance of Phosphorus

Phosphorus is required in more sums by young tissues of citrus trees, such as shoots and root tips for cell division and quick assimilation. Mong et al. (2006) uncovered an enormous extension in plant stature and plant stem estimation when they were given Phosphorus at a speed of 126 grams for each tree yearly.

Phosphorus is critically needed in more amounts by youthful tissues of trees, for example, shoots and root tips for cell division and fast digestion. Mongaa et al. (2006) revealed that there was a huge expansion in plant tallness and plant stem width when they were applied with Phosphorus at a pace of 130 g for every plant yearly.

The crucial inspiration driving soil usage of mineral segments is to improve working feasibility of plants. Potassium is required in greater entireties by citrus plants for strong reap yield, so it is for the most part given to the trees through soil content. Citrus with maximum spread and significant root structure has higher enhancement essential than various yields. Plant connects are skilled in taking water and soil enhancements; subsequently, they are ordinarily given into the earth (Mengal, 2004). Soil application can give palatable enhancements to all the more promptly plant creation (Feast et al., 2004). Sensible soil pH oversees supplement availability and helps in transport of enhancements through soil to tree, so soil application is more impressive than foliar shower in such soils. Foliar application is more intelligent to supply supplemental segments or small enhancements. Further, foliar showers of macronutrients are great exorbitant than soil application (Zakri and Obriza, 2005).

1.5 Importance of Potassium

Potassium is one of the significant large-scale supplements and it is needed as high as Nitrogen and Potassium since it improves the mineral substance of organic product, yield just as Quality (Wea et al., 2004). Dissimilar to other full scale supplements K doesn't establish any piece of natural mixtures or plant structures; it assumes part in various biochemical just as physiological cycles and has a significant job in tree development (Cakmaak, 2007). In tree tissues, Potassium levels varies from one to three percent by weight, that is underdog to Nitrogen. Potassium particles are exceptionally portable in plant framework, yet less versatile in soil. Being a fundamental component, Potassium assumes a key part in the development of proteins, sugars, and fats and their appropriate working; it also assists with controlling water supply in plants (Liua et al., 2002). Recently amalgamation starches are moved and added to the plant framework through the legitimate inventory of K. It holds the stomatal conductance accordingly it controls supply of CO2 to citrus plants and eventually keeps up supply of sugar content (Srivistava, 2015). Overabundance or insufficiency of any component may seriously influence the plant wellbeing. Upgraded level of K may bring about bigger size natural products with thick and greenish strip. More K sustenance level expanded juice sharpness. K is a significant indispensable component engaged with different marvels; nonetheless, its insufficiency may cause the decay of both vegetative just as regenerative developments. It is accounted for that practically 60% developed soils have development restricting issues that are connected with mineral supplement poison levels or inadequacies (Cakmak, 2006). K inadequacy is for the most part revealed in acidic and sandy soils because of generous filtering and trees may show less photosynthetic exercises. Plants with potassium lack are exceptionally less touchy which quickly foster chlorotic or necrotic manifestations when they are presented to all the lighter power or some other pressure like dry spell. With potassium lack, perceptible manifestations can be seen over the tree, such as more modest leaf size, diminished plant development, hefty leaf fall, and yellow leaves. It is accounted for that a little lessening in potassium sustenance may falls apart vegetative tree development (Srivastava, 2015). Inadequacy of Potassium at beginning phases of plant development shows hindered development, inadequate tanned foliage and leaves with blurred appearance. While, with extreme Potassium inadequacy, leaves become wrinkled and curved and plant arises week parallel shoots because of absence of the mechanical strength. Potassium lack diminishes natural product quality and yield; heavy organic product drop happens because of the inadequacy. Influenced trees produce products of more modest size with flimsy strip and smooth surface which may show pre-shedding. As per Aliva et al.(2008b) low Potassium accessibility decreased juice acridity in lemon.

K sustenance emphatically affected the actual organic product quality boundaries like natural product size, weight, strip thickness and juice substance, which are considered generally significant for table reason or new utilization of organic products. K application altogether expanded organic product size in 'Valencia' oranges with expanding the potassium levels, most extreme natural product weight 215 g was noticed with the utilization of 227 kg K/ha, when contrasted with control (Quagio et al., 2008). Nitrogen and Phosphorus applications improved the organic product weight in 'Kinnow' though, most extreme organic product weight about 152g were noticed in field by applying S.O.P. @ 102 kg/ha (Mongaa et al., 2005).

Citrus natural product strip is advanced with oil substances likewise utilized as enhancing specialists in different food varieties. Strip thickness is essential for good quality organic products as fat strip is not difficult to eliminate from natural product like in grapefruit etc. Thick strip gives insurance to juice and mash against drying of the organic product. Most extreme strip thickness of 'Kinnow' mandarin was gotten by feeding the trees with higher K levels alongside Nitrogen and Phosphorus (Abad-Allah, 2009).

Chapter 2

MATERIALS AND METHODS

The following experiment was conducted at the Experimental Fruit Garden in Bhalwal city district Sargodha during 2019-2020 on Citrus reticulata. 'Kinnow'. Fifteen-year-old 'Kinnow' mandarin trees budded on the Rough Lemon (Citrus jambiriL.) root stock grown at closer spacing were selected. The experiment was laid out in an orchard by random sampling technique soil samples were collected from an orchard of 25 acres. Then these samples are packed in a plastic bag for laboratory testing of macro and micro nutrients. Leaf samples were also collected from the same area and then sent to the laboratory for further analysis after proper treatment. N.P.K. electronic conductivity and soil pH was tested in the laboratory under controlled atmosphere. Single orchard was taken as an experimental unit and analysed many times along with different parameters. All the experimental trees were subjected to the same farming and agricultural practices such as irrigation, weeding, plowing, insect pest and disease control.

2.1 Study Area

Bhalwal is selected as a study area, it is situated in the Sargodha district of Punjab, Pakistan (Figure 3.1). Bhalwal is among one of major citrus production area in Pakistan. It lies between Chenab and Jhelum River. Its overall weather conditions are 19°C, Wind NE at 0 km/h, 77% Humidity, favorable conditions for citrus production. Sargodha is one of the largest Kinnow producing districts of the world and is also called “CALIFORNIA OF PAKISTAN”. Kinnow production has a significant role in Pakistan's agricultural economy.Figure 3.1.

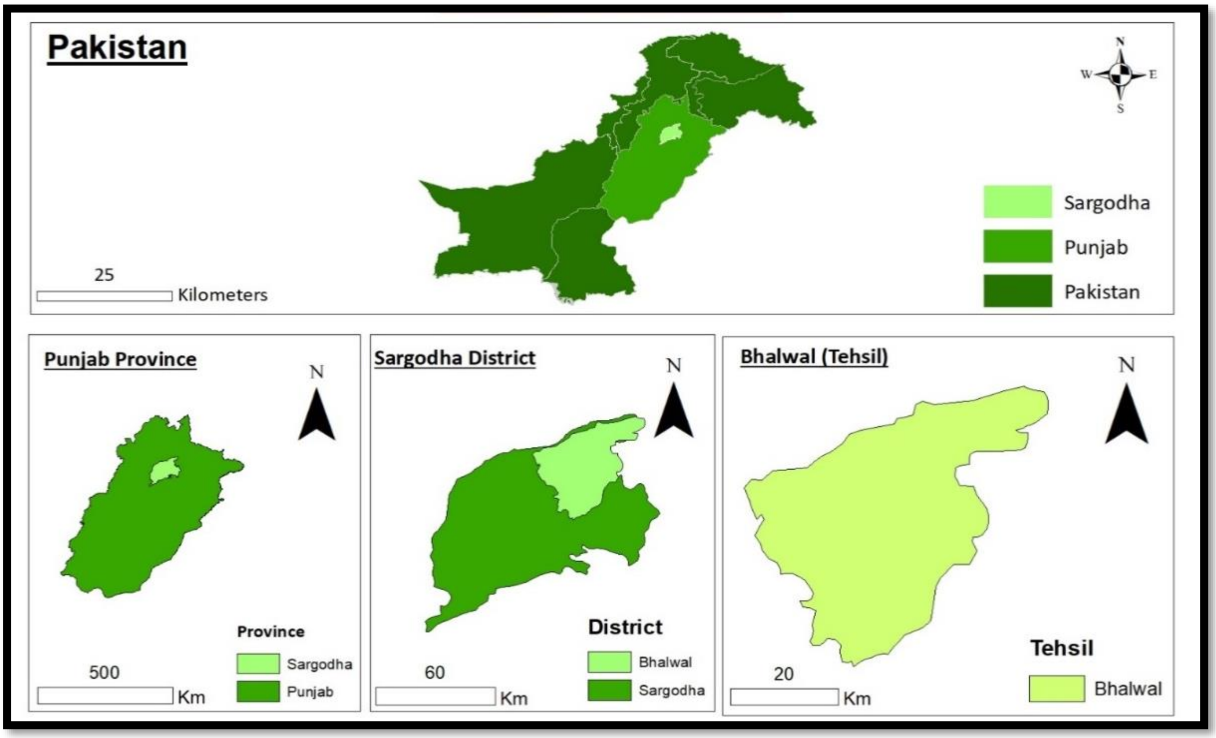

Figure 3.1. Study area map.

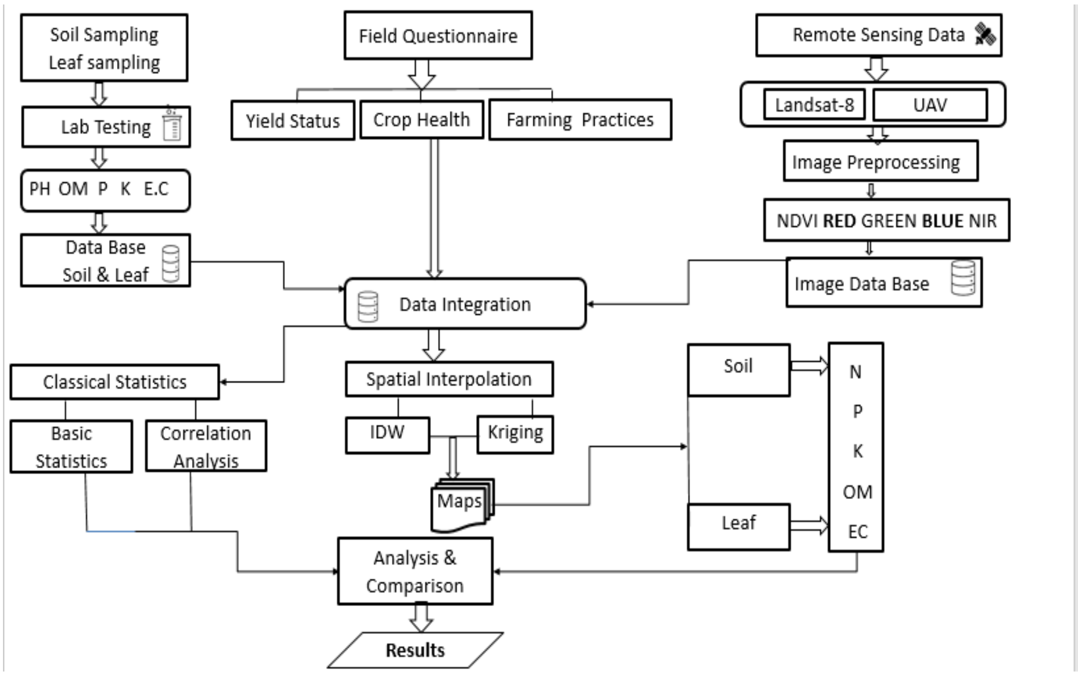

Figure 3.2. Generic methodology flow cart.

2.2 Soil Sampling & Laboratory Analysis

Soil tests were shipped in impenetrable sacks to the research center where they were gone through stove dry strategy (Zhaang, 2012), further squashed for sifter (Beeuselinck, et al., 1999) and hydrometer investigation (Ween, et al., 2004) to gauge soil supplements. Soil compound properties (O.M., N, P, K, pH) were assessed for each example. The research center determined soil O.M. utilizing the Walkley-Dark chromic corrosive wet oxidation technique (Scchumacher and B.A, 2004). Soil N was determined utilizing Kjjeldhal refining unit (Uygur, et al., 2010), Soil P was determined utilizing Ollsen's Technique (Sims, 2002), Soil K was determined utilizing Fire photometer (Jiaxiin, et al., 2018) and other hardware, Soil pH was resolved utilizing Spatula, and pH meter (Pech, 1968). Soil E.C was resolved utilizing Conductivity Meter and assistant hardware at 25 ºC with pressing factor of 1 air (Smmith, et al., 1997). Soil samples were collected from orchard of kinnow by random sampling technique through auger. soil sampling equipment provides a fast and accurate way to profile soil layers and obtain a collection of core samples for classification and testing for an array of soil types. Almost 23 soil samples were collected from an area of 25 acers and then these samples were packed in plastic bags and after packing sent to laboratory for further analysis of N.P.K., E.C. and P.H. For the examination, 19 examples were chosen to utilize irregular inspecting methodology barring regions not appropriate for soil testing, for example, thick vegetative region and so on The exact area of examining focuses was situated by a Garmin worldwide situating framework (Drosoos, et al., 2012). Examining of every individual point was completed in space of 1 m2 and from the best 5 cm of the dirt vertical profile. Inspecting was done in clear climate conditions in August 2019. Soil Tests were gathered utilizing Instruments given by Fauji compost organization. Subtleties of instruments are as under. Warm climate was a major test during this errand.

1. Core Cutter
2. Digging apparatus
3. Soil Auger

2.3 UAV Data & Preprocessing Of All The Data

In corresponding to physiochemical credits assessment Far off Detecting information Landsat-8 Pictures [Path 148, Column 38] were obtained from USGS Earth voyager. Satellite information handling (Layer Stacking, Picture mosaicking, spatial Sub setting, Radiometric Amendment, Histogram Adjustment) were completed in Erdas Envision 2020 (Yung, et al., 2018). Standardized Contrast Vegetation Record (NDVI), (Hadjimitsis, et al., 2010) were determined utilizing Erdas Model Creator. An incorporated Esri Document Geodatabase was made with field overview information focusing on every compound property, landsat-8 groups, UAV information NDVI esteems. Table 1 clarifies exhaustively rundown of software's, and informational indexes utilized in the examination. Figure 3.2 portrays general outline of strategy utilized which is clarified in later segments exhaustively.

2.4 Pruning Method, Leaf sampling and Analysis

Pruning was done physically by utilizing pruning scissors prior to blossoming during last seven-day stretch of February. For exact support width, two posts were fixed at the two closures of column at both sides keeping a specific width between firmly planted trees and attached with a hard rope. The branches out of the ropes were pruned evenly with saw and pruning scissors. Dead, undesirable and infected influenced branches were additionally taken out. Heavy branches were cut with the assistance of a saw while slim branches were eliminated by cutting scissors. For leaf investigation, develop and solid leaves for example with no infection and insufficiency indications were gathered from exploratory trees cautiously from entire covering. Examining was completed multiple times first before manure application on sixteenth February, 2019 and second after compost application on seventh September, 2020. Around 50 leaves were gathered and brought in paper packs to the research centre for additional examination. Develop leaves from 'Kinnow' mandarin trees were gathered arbitrarily and were broke down for Nitrogen, Phosphorus, Potassium fixations when the trial medicines Figure 3.2.

2.5 Sample Preparation and Identification of All Nutrient Elements (Soil & Leaf)

Leaves alongside their petioles were washed with faucet water and afterward with cleanser what's more, again with faucet water lastly with all around washed refined water for 2-3 times so that the impact of cleanser was cleaned out. A short time later the leaves were dried under conceal for 48 h and afterward were pressed in punctured paper packs. Subsequent to naming, packs were punched and set in broiler for drying at 60oC for more than 48 h. The dried leaf tests were then taken out and crushed to fine powder in an electric tempered steel processor. This powder was put away in appropriately named hermetically sealed plastic containers at room temperature for additional investigation. N.P.K. and some other parameters like Ph electronic conductivity of soil and leaf were analyzed in the laboratory.

Table 1 Data sets and software used.

Data	Description	Source
Soil chemical properties	Lab analysis of soil O.M., pH, K, P	Soil samples collected from the study area through field survey
UAV Imagery	Matrice 100 DJI	Imagery was collected from the study Area through Field survey
Leaf chemical properties	Lab Analysis of leaf N, P, K	Leaf samples collected from the study area through field survey
Soil sample location	Geo referencing of soil samples	Garmin G.P.S. was used to collect soil sampling location
Software Used		
ArcGIS (10.8) and GeoDa	Geospatial analysis	ESRI and University of Chicago
Erdas Imagine	Satellite imagery analysis	Intergraph
PIX4Dmapper	Drone Data Pre-Processing	
Microsoft Excel	Data Analysis	Microsoft

Chapter 3

RESULTS AND DISCUSSION

3.1 Descriptive Statistical Analyses

Table 2 shows results of soil nutrients using classical statistics 19 samples were collected and analyzed using min, m.a.x., average, s.t.d., skewness. It was observed that Soil OM ranges between (0.59 % - 0.74 %), with mean value 0.66, Nitrogen values varies from (0.04-0.05) % with mean value of N 0.04, P values varies from (1.00-6.00) ppm with mean value 2.84, K values varies from (125-239) ppm, with mean value 175.47, OM values varies from (0.59-0.74) %, with mean value 0.66, Soil pH ranges from (8.00 – 8.80), having mean value of 8.27. Soil EC ranges between (0.21 – 0.51) (dS/m), having mean of 0.29. Na_Ex ranges between (0.60 -1.90), having mean value 0.96. Yield values ranges from (4.00-7.00) tons per hectare, with mean value 5.47. Table 3 shows significant variables at 0.05 level using correlation matrix, it was observed that soil K and P were statistically significant at 0.66, Soil O.M. and Nitrogen were found to be statistically significant at 0.90 and Na_Ex and P.H. were statistically significant at 0.82.

3.2 Classical Statistical Exploration

Table 4 show results of soil nutrients using classical statistics 19 leaf samples were collected and analysed using min, m.a.x., average, s.t.d., skewness. It was observed that leaf Nitrogen values varies from (1.040-2.130) % with mean value of N 1.479, P values varies from (0.036-0.240) % with mean value of P 0.092, K values varies from (0.580-2.340) %, with mean value of K 1.312, Yield values ranges from (4.00-7.00) tons per hectare, with mean value 5.474. Table 5 shows significant variables at 0.05 level using correlation matrix, it was observed that leaf N and P were statistically significant at 0.56.

Table 2 Summary Statistics of soil Nutrients.

Statistics	***N (%)***	***P (%)***	***K (%)***	***O.M. (%)***	***pH***	***EC (dS/m)***	***Na_ Ex (mmolc/100g)***	***Yield (t/ha)***
Mean	0.04	0.0003	0.02	0.66	8.27	0.29	0.96	5.47
Median	0.04	0.0003	0.02	0.64	8.20	0.27	0.80	5.00
Mode	0.04	0.0003	0.02	0.64	8.20	0.24	0.80	5.00
Standard Deviation	0.00	0.0002	0.00	0.04	0.23	0.08	0.40	1.02
Kurtosis	-0.67	-0.1140	1.52	-0.75	-0.12	1.53	1.89	-0.95
Skewness	0.06	0.7687	1.39	0.39	0.82	1.33	1.80	0.25
Range	0.01	0.0005	0.02	0.15	0.80	0.30	1.30	3.00
Minimum	0.04	0.0001	0.01	0.59	8.00	0.21	0.60	4.00
Maximum	0.05	0.0006	0.03	0.74	8.80	0.51	1.90	7.00

Table 3 Correlation matrix of soil Nutrients

Variable	***N (%)***	***P (%)***	***K (%)***	***OM (%)***	***pH***	***EC (dS/m)***	***Na-Ex (mmolc/100g)***	***Yield (t/ha)***
N (%)	1							
P (ppm)	-0.02	1.00						
K (ppm)	-0.13	0.66	1.00					
OM (%)	0.90	-0.01	-0.13	1.00				
pH	0.21	-0.21	-0.10	0.16	1.00			
EC (dS/m)	0.06	-0.08	-0.01	-0.22	0.12	1.00		
Na-Ex (mmolc/100g)	0.19	-0.11	0.04	0.06	0.82	0.38	1.00	
Yield (t/ha)	-0.04	0.19	0.12	-0.01	-0.31	0.01	-0.14	1.00

Table 4 Summary statistics of Leaf Nutrients

Statistics	**N (%)**	**P (%)**	**K (%)**	**Yield (t/ha)**
Mean	1.479	0.092	1.312	5.474
Median	1.450	0.079	1.350	5.000
Standard Deviation	0.335	0.055	0.397	1.020
Kurtosis	-1.174	1.651	2.001	-0.954
Skewness	0.368	1.428	0.219	0.255
Range	1.090	0.204	1.760	3.000
Minimum	1.040	0.036	0.580	4.000
Maximum	2.130	0.240	2.340	7.000

Table 5 Correlation Matrix of Leaf Nutrients

Variable	***N (%)***	***P (%)***	***K (%)***	***Yield (t/ha)***
N (%)	1			
P (%)	0.56	1.00		
K (%)	-0.06	0.06	1.00	
Yield (t/ha)	-0.06	-0.15	-0.19	1.00

3.3 Descriptive Statistical Analyses

Table 2 show results of soil nutrients using classical statistics 19 samples were collected and analyzed using MIN, M.A.X., AVERAGE, S.T.D., SKEWNESS. It was observed that leaf Nitrogen values vary from (0.58-2.34) % with mean value of N 1.31, P values vary from (4.0-0.7.0) % with mean value of P 5.50, K values varies from (8460.00-9055.00) %, with mean value of K 8710.94, Yield values ranges from (8086.00-9071.00) tons per hectare, with mean value 8492.11. Blue Band and red band reflectance vary (0.13-0.27), with mean of 0.18. Near-NIR band reflectance varies from (11168-14506), with mean value 12229.63. NDVI reflectance varies from (0.13-0.27), with mean value of 0.18. From Table 3 shows significant variables at 0.05 level using correlation matrix, it was observed that leaf N and P were statistically significant at 0.56. From Table 6 Near-NIR and N statistically significant at 0.44 and NDVI and N were also statistically significant at 0.49. Blue band and yield were also statistically significant at -0.43, Red band and yield were also statistically significant at -0.48.Table 7 shows Correlation Matrix of Leaf Nutrients and UAV imagery.

3.4 Geospatial Interpolation for Soil Mapping

I.D.W. (Inverse Distance Weighted) and kriging are famous interpolation techniques. General equation of kriging was discussed. Chemical properties were first explored using I.D.W. and kriging, based on predicted raster, accuracy assessment was performed by using RMSE (Root Mean Square Error) using known values of each sampled points. Soil O.M. & E.C were better predicted using kriging approach. Soil pH, P & K were explored better using I.D.W. interpolation method.

Table 6 Summary Statistics of citrus Leaf Nutrients and UAV Data

Statistics	N (%)	P (%)	K (%)	Yield (tons/ha)	NDVI
Mean	1.48	0.09	1.31	5.47	0.18
Median	1.45	0.08	1.35	5.00	0.17
SD	0.34	0.06	0.04	1.02	0.03
Kurtosis	-1.17	1065	2.00	-0.95	2.36
Skewness	0.37	1.43	0.22	0.25	1.47
Range	1.09	0.20	1.76	3.00	0.14
Minimum	1.04	0.04	0.58	4.00	0.13
Maximum	2.13	0.24	2.34	7.00	0.27

Table 7 Correlation Matrix of Leaf Nutrients and UAV imagery

Correlation	***N (%)***	***P (%)***	***K (%)***	***Yield (t/ha)***	***Blue Band***	***Green Band***	***Red Band***	***Near-NIR Band***	***NDVI***
N (%)	1.00								
P (%)	*0.56	1.00							
K (%)	0.06	0.06	1.00						
Yield (t/ha)	0.06	0.15	0.19	1.00					
Blue Band	0.07	0.02	0.13	*-0.43	1.00				
Green Band	0.16	0.10	0.23	-0.39	0.97	1.00			
Red Band	0.05	0.03	0.08	*-0.48	0.96	0.90	1.00		
Near-NIR Band	*0.44	0.25	0.38	-0.10	*0.48	0.65	0.30	1.00	
NDVI	*0.49	0.31	0.37	0.11	0.08	0.29	-0.12	0.91	1.00

3.5 Statistical Exploration

To achieve objective of research first phase was to explore data using classical statistics, Min, Max, average, std, & skewness were calculated as listed in Table 2. Data was checked for discrepancies and outliers (Borujeni, et al., 2010). Correlation was calculated among chemical properties as listed in Table 3. Using same methodology correlation among remote sensing data was calculated, Table 7 shows significant parameters at $p \geq 0.05$ level. Multiple linear regression (*M.L.R.*) modelling was applied on various chemical properties as y independent and multiple x explanatory variable (Forkuor, et al., 2017) defined as y = a + x 1 + x 2 + x 3 + ……. + x n + Σ e, where Σ e, is residual. Limitation of applying classical statistics on spatial data were sighted out to assess the prediction accuracy, the coefficient of determination R^2 & the Root Mean Square Error (*RMSE*) were calculated.

3.6 Geospatial Interpolation for Soil Mapping

Apart from above modelling approaches, geospatial interpolation was applied on soil data. (Mitas, et al., (1999) defines interpolation as $F(rj) = Z(j)$, $j = 1, ..., N$ *for N values of observations* $Z(j), j = 1 \ldots\ldots N$ measured at Point $rj = xj\,[1],\ xj\,[2], \ldots, xj\,[d]\,),\ j = 1, \ldots, N$ within space, finding d-variate function $F(r)$ which crosses given points. Inverse Distance Weighted (*I.D.W.*) interpolation uses a weighted average of values at known sample locations to predict unknown points (Belief, et al., 2018). Mathematically I.D.W. equation is represented below where m is the number of closest points, p is parameter usually 2 (Watson, (1992).

$$F(r) = \sum_{i=1}^{m} w_i z(r_i) = \frac{\sum_{i=1}^{m} \frac{z(r_i)}{|r-r_i|^p}}{\sum_{j=1}^{m} * \frac{1}{|r-r_j|^p}} \qquad \text{………………….. Equation 3.1.}$$

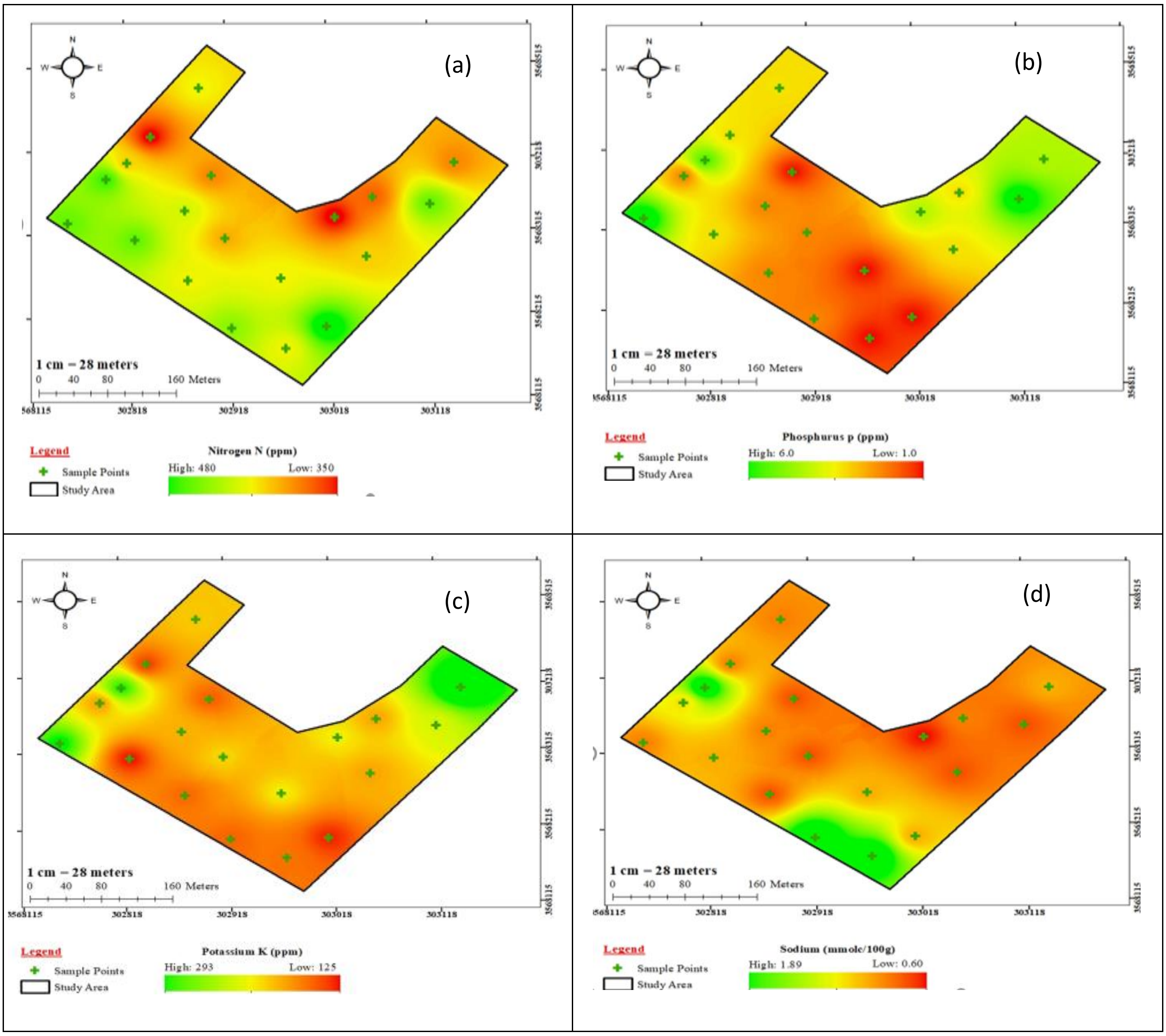

Figure 3.3. Maps of parameters (soil and leaf) (a)shows Soil Nitrogen, (b) shows Soil Phosphorus, (c) shows soil Potassium and (d)shows Soil Sodium.

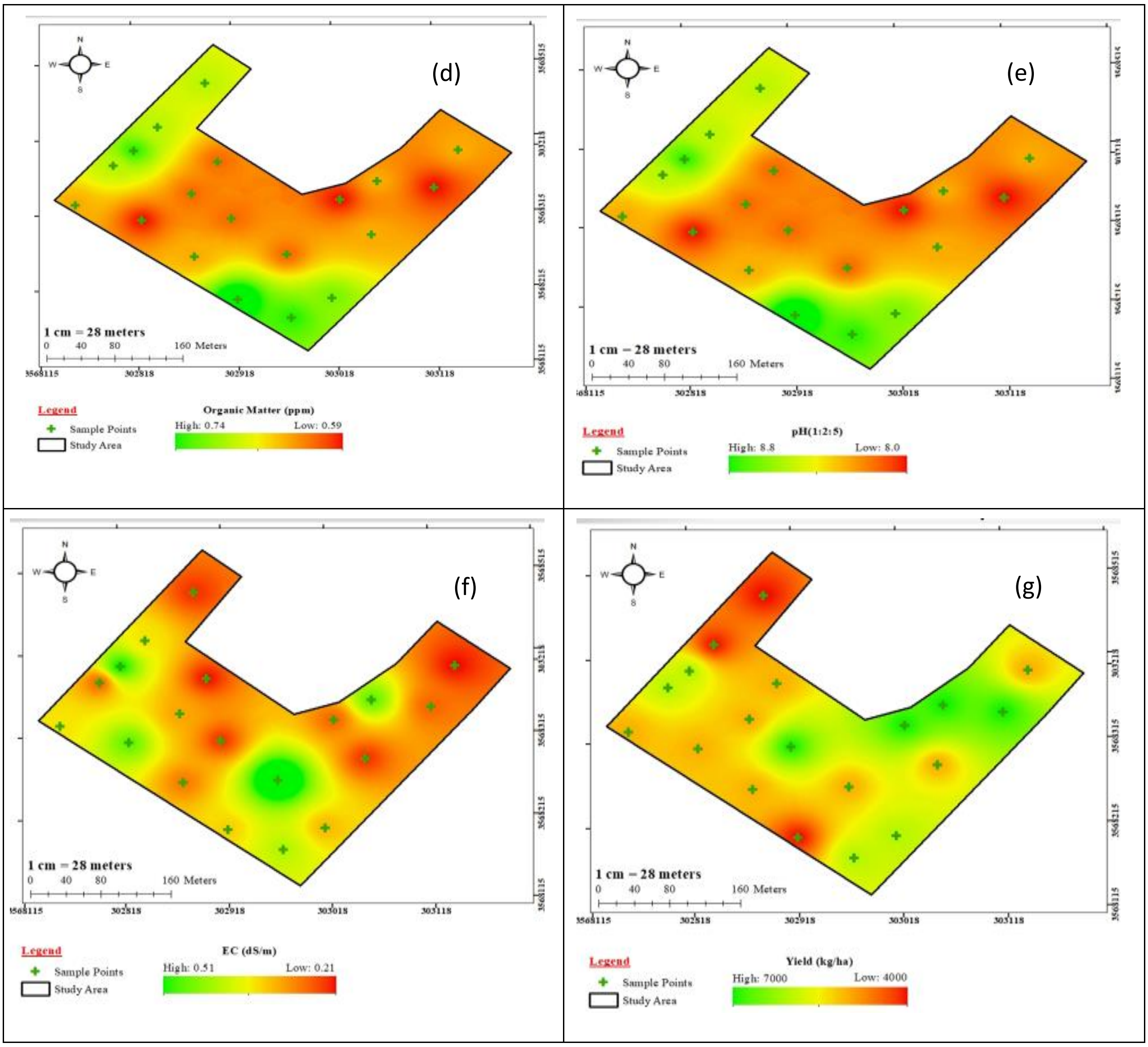

Figure 3.4. Maps of parameters (soil and leaf) (d) Show Soil organic matter, (e) shows soil pH, (f)Shows Soil Electrical Conductivity and (g) shows Yield Map of study Area.

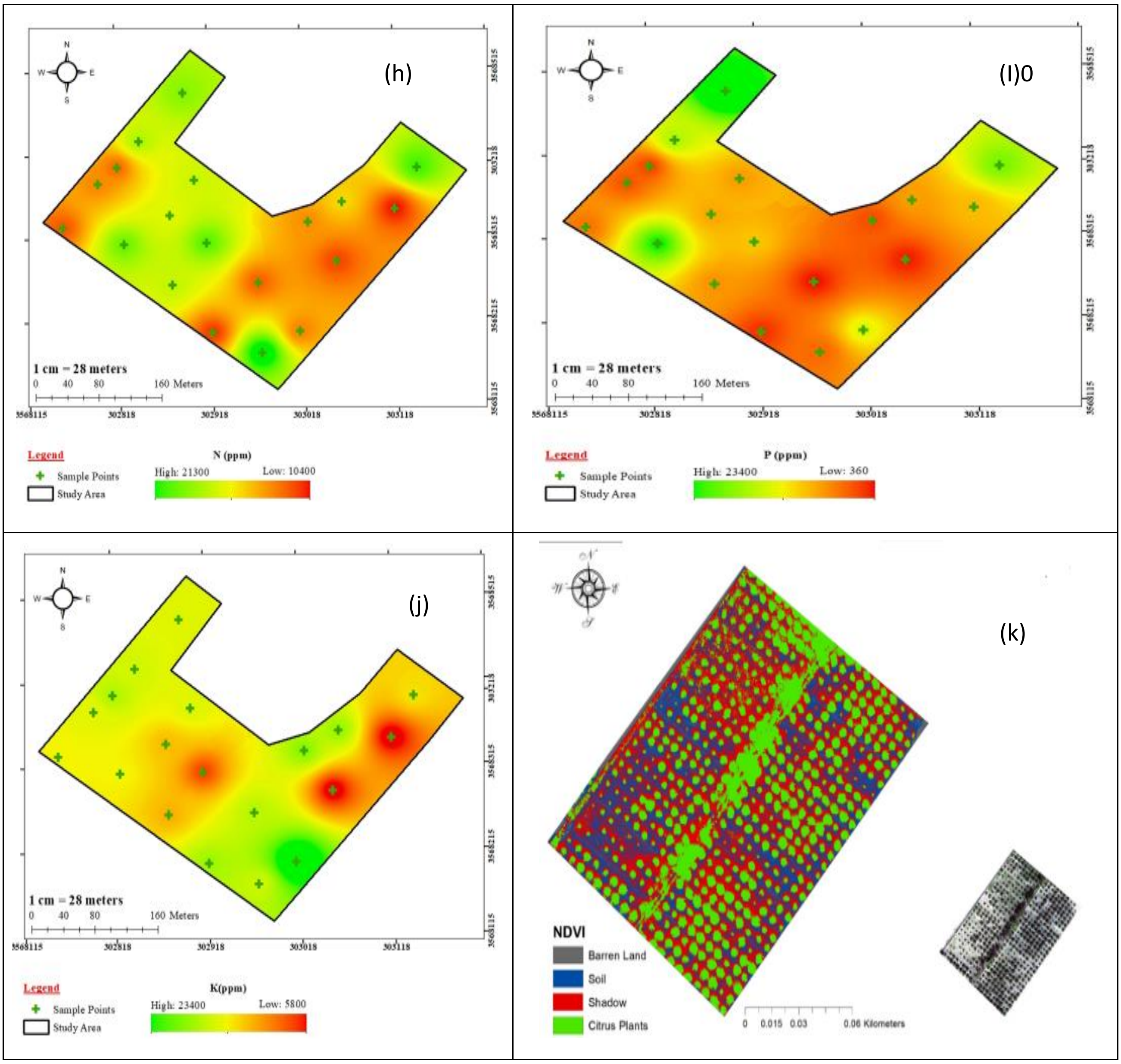

Figure 3.5. Maps of parameters (soil and leaf) (h) Leaf nitrogen, (i) shows Leaf phosphorus, (j)shows Leaf potassium and (k) shows NDVI of study Area.

Chapter 4

CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

For leaf nutrient determination, leaf sampling of 'Kinnow' mandarin tree was taken along with soil samples. Before laboratory testing, macro leaf nutrients such as Nitrogen (N), Phosphorus (P) and potassium (K) were in the deficient range. After soil laboratory testing, most of the nutrients was in low range. Different pruning levels significantly affected vegetation growth, such as tree height, tree spread, flush length, and the number of leaves per flush. However, different N.P.K. compound fertilizer treatments exhibited a non-significant effect on the vegetative growth of 'Kinnow' mandarin tree except the average number of recorded leaves maximum. While other parameters like trunk girth, leaf length and leaf width showed non-significant results for both pruning and N.P.K. levels.

Reproductive growth of experimental trees was significantly affected by pruning levels as well as N.P.K. treatments. Likewise, higher number of fruits, yield and lowest fruit drop was recorded in trees treated with proper compound fertilizer treatment per tree. Fruit physical parameters such as fruit weight, fruit width, fruit length, peel thickness, average number of seed and seed weight were significantly affected by various pruning intensities. Hence, it can be concluded that deficiency in soil and leaf nutrients had a negative effect on growth, production, and Quality of 'Kinnow' mandarin grown under high density plantation. Severe pruning significantly enhanced vegetative growth (tree height, flush length and no. of leaves), reproductive growth (number of fruits, fruit drop percentage and yield), physical (fruit weight, fruit width, fruit length. However, considering the growth habit of these 'Kinnow' mandarin trees, further studies are required for two to three years to standardize and confirm these results. In our case, the values of Nitrogen in the leaf was 1.04 % to 2.13 % however, the standard value varies from 2.2 to 2.8 %. A small portion of the study area has 1.04 %, while the majority of the study area has optimum value. Phosphorus optimum values varies from 0.12% to 0.16%. However, the study area shows 0.036 % to 0.240 %, which is also optimum. Potassium optimum values varies from 0.7 % to 1.7 %. However, the majority of the values were in the optimum range of 0.580 % to 2.340 %, except few outliers.

In soil sampling, Nitrogen values vary from (0.04-0.05) %; however, the optimal range of Nitrogen in soil profile is (2.2-3.0) %. It shows that soil nitrogen was facing a serious deficient. Potassium values varies from (125.0-293.0) ppm and phosphorus values varies from (1.00-6.00) ppm, Organic matter value varies from (0.59-0.74) %, while average value lies between (3-6) %, pH value lies between (8.00-8.80), while the average value for healthy soil is (6.00-7.00), Electric conductivity of soil varies from (0.690-1.90) ds/m.

4.2 Recommendations

Traditional farming practices for Agriculture are outdated and must be replaced by precision agriculture based on G.I.S. and Remote Sensing approaches. Geospatial Statistics and G.I.S must replace modeling approaches for soil and leaf prediction. Models. Satellite Images with high spectral and spatial resolution can further improve this research subjected to cost. Drone-based crop monitoring can be achieved with significantly less cost and accuracy using these techniques. Soil and leaf nutrient deficiency can be controlled by laboratory analysis of soil and leaf and their proper solutions. Both quality and quantity of Citrus can be improved using new monitoring techniques and proper laboratory analysis.

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