Research Article

Zinc status of apple orchards across apple growing regions of Balochistan

Hidayatullah1*, Gul Muhammad Panezai2, Rehmatullah Kethran2, Syed Abdul Hadi Agha2, Nazeer Ahmed Alizai2 and Zainullah Khan3

1. Directorate of Agriculture Research Soil and Water Testing ARI Sariab Quetta-Pakistan
2. Directorate of Agriculture Research (Fruits) ARI Sariab Quetta-Pakistan
3. Directorate of Agriculture Research Grapes Pishin-Pakistan

*Corresponding author’s email: kaintkk@gmail.com

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Abstract
All plant essential nutrients except Molybdenum are not easily available in alkaline calcareous soils. Among them, the deficiency of micronutrients particularly Zinc and iron is widespread in crops and fruit orchards. For this purpose, a survey study was carried out across five districts of Balochistan viz Kalat, Killa Abdullah, Pishin, Quetta and Ziarat during 2016 aiming to determine both soil and leaf Zn status of apple orchards. The 150 soil and leaf samples were collected and statistically divided them as 30 samples of each district in 3 groups of 10 samples and analysed through one way analysis of variance. The results showed that soil pH of apple orchards was in alkaline range and EC was almost normal with statistically at par differences. While, the AB-DTPA extractable Zn in soil of various apple orchards across five districts revealed that 5, 23 and 2 orchards in Kalat, 3, 24 and 3 in Killa Abdullah, 15 15 and 0.0 in Pishin and Ziarat while 20, 10 and 0.0 in Quetta expressed low, marginal and adequate Zn concentration. The leaf tissue analysis for Zn status indicated that 23.3% apple orchards in Kalat, 6.7% in Killa Abdullah, 33.3% in Pishin, 73.3% in Quetta and 56.7% in district Ziarat were found Zn deficient. Consequently, this study suggest that Zinc supplementation to soil of these orchards are needed while the addition of compost under such alkaline soil also necessary and is considered as one of the best management practices for apple orchards.

Keywords: Apple orchards; Leaf Zn concentration; Locations; Soil Zn concentration

Introduction
In agriculture, the zinc (Zn) has been recognized significantly one of the important mineral elements. The role of Zn as plant essential element and development of its essentiality was realized slowly [1]. The historical background of Zn indicate that during 1869 the student of Louis Pasteur viz Raulin first time described Zn requirement as nutrient for the prosper of fungi (Aspergillus niger) causing diseases in many agricultural crops like black mold disease of grapes, onion and peanuts. When Zn was confirmed as an essential element for growth of plants, now globally many areas have been identified deficient in Zn level and have adverse impact on growth performance and yield of crops, vegetables and fruits orchards. It has been reported that Zn status is found low in sandy and peat soils [2]. In calcareous soil, the deficiency of micronutrients particularly Zn is prevalent among all agriculturally important crops since the unavailability of Zn in such soil is...
due to its adsorption on clay and calcite, low Zn in the parent material, alkaline nature (high pH), high calcium carbonate contents, high or low soil organic matter. While Zn deficiency in calcareous soil is also due to the dominancy of sodium (Na), calcium (Ca), magnesium (Mg), HCO$_3$ and high phosphorus level in soil [3, 4]. In Pakistan including the province of Balochistan, the reasons of low soil Zn status in orchards is linked to calcareous and alkaline nature of soil with low organic matter and in some cases the light soil texture is also responsible for Zn deficiency. While, the high contents of calcite make Zn unavailable by making calcium zincate which is insoluble [5]. In an approximation, the out of total area of the world 30-40% area is deficient in Zn [6, 7] as in case of Pakistan, due to unavailability of nutrients under calcareous soil the average yield of apple orchard is 3.9 t ha$^{-1}$ [8] which is quite low when compared to other neighboring countries. According to Lindsay [9] that a unit increases in soil pH correspondingly reduce the availability of Zn 100 times. The scientific literature has manifested that most of fruit trees are vulnerable to Zn deficiency and among deciduous fruit trees, apple are highly susceptible to Zn deficiency [10, 11]. Each nutrient plays a specific function in bio-physico-chemical process of all living things. In case of Zn, its presence in sufficiency range is crucial because Zn is essential nutrient required for the proper growth performance of plants as it play role in bursting of fruit buds, fertilization and reproduction and also equally important for sound health of human beings and animals. While, in some regions of the world soil and water contamination with Zn which reach to us through food chain [12-14]. Zinc main function is catalytic in nature for different enzymes [15]. These enzymes are involved in different biochemical processes like carbohydrate metabolism, protein synthesis, integrity of cell membranes, pollen development and auxin production. Other function of Zn in plants involved metabolism of nitrogen and its deficiency results in low protein production with stunted plant growth [15, 16]. Spatial variability in soil Zn status of Agriculture land has been noticed and has found to be ranged from 10 to 300 mg kg$^{-1}$ [17, 18]. While, in scientific reports the average soil Zn was noted about 50-55 mg kg$^{-1}$ [19]. Whereas, the world’s soil average Zn contents was indicated as 64 mg kg$^{-1}$ [20, 21]. The Zn deficiency has also been expressed in early growing seasons where temperature is low as well as in cool and wet soils that later on disappear when summer comes. The reason of low soil Zn is due to slow decomposition of organic matter by soil microbes during cool season that works as a slow release of Zn for crop. Inversely, rise in soil temperature lead to enhance Zn availability by increasing diffusion rate and accelerate organic matter mineralization rate [3]. In light of the importance of Zn in apple fruit production and its unavailability in calcareous and alkaline soil, this study was initiated to determine the soil and leaf Zn status of apple orchards in five districts of Balochistan, Pakistan.

Materials and methods
A field study was conducted during 2016 to evaluate the zinc status of apple orchards belonging to five districts of Baluchistan viz. Kalat, Killa Abdullah, Pishin, Quetta and Ziarat. The study consisted of two components, the first one involved the assessment of soil physico-chemical properties such as pH, electrical conductivity (EC), ammonium bicarbonate-diethylenetriaminepentaacetic acid (AB-DTPA) extractable Zn. while the second component comprised of leaf tissue analysis for determination of Zn in fruit bearing apple orchards.
Thirty fruit bearing apple orchards of same age and variety (red delicious) were selected from different locations in Kalat, Killa Abdullah, Pishin, Quetta and Ziarat district of Baluchistan. Five trees were randomly selected from each orchard and composited for one sample. This way a total of 150 each soil and plant samples were collected.

**Soil and leaf sampling and processing**

Fifteen to twenty recently matured leaves were collected from the mid-portion of branch, covering the tree periphery and composited to one [22]. Soil samples from same trees were collected at the depth of 0-30 cm. In order to have a representative soil sample from each tree, four to six cores were dug underneath the tree canopy and composited to one. All the soil and leaf samples were properly labeled and delivered to the Soil and Water Testing Laboratory of Agriculture Research Institute (ARI), Quetta. The soil samples were air dried, ground and sieved through 2 mm mesh. Whereas, the leaf samples were decontaminated and washed [23], oven dried at 65°C [24], ground to 20 mesh and stored in plastic bags for target analysis.

**Soil and leaf analysis**

The soil was analyzed for some physico-chemical properties by standard methods. Soil electrical conductivity (EC) and pH were determined in 1:2 soil water extract using EC meter and pH meter according to the method described by McKeague [25] and McLean [26]. While, AB-DTPA extraction solution was used for extracting soil Zn [27]. In the clear filtrate of AB-DTPA soil extract, Zn was determined on Atomic Absorption Spectrophotometer at 880 nm wavelength.

From the prepared leaf samples, 0.5 g was weighed and wet digested using hot sulfuric acid with repeated additions of 30% hydrogen peroxide (H₂O₂) until the digestion was completed, then this digest was used for the determination of zinc [28].

**Statistical analysis**

The collected data were subjected to one-way analysis of variance and also used descriptive statistics for determination of minimum, maximum and mean values and percentage. All statistical analysis was computed on Statistix 8.1 software (MathSoft Inc., Cambridge, MA, USA).

**Results and discussion**

In Balochistan province, apple fruit production occupies major position among deciduous fruits and is the main source of income of people in uplands of Balochistan. The main apple growing districts of Balochistan are Kalat, Killah Abdullah, Killa Saifullah, Mastung, Pishin, Quetta, and Ziarat. The contribution of Balochistan in deciduous fruits is higher as compared to other provinces of Pakistan and now Balochistan is called the “fruit basket” of Pakistan. However, both yield and quality of apple has declined to great extent which might be due to changes in environment, water scarcity and lack of adoption of best management practices. Soils in Pakistan including Balochistan is calcareous and alkaline in nature where nutrients availability to plants is one of the main constraints in agriculture production along with apple orchards enterprises. The micronutrient particularly zincs and iron deficiencies are widespread in all apple growing districts which have now affected growth and yield of apple substantially. So, for the assessment of zinc status of apple orchards, soil and leaf samples from apple orchards in 30 locations of each district were collected and analysed. There was great variability in the AB-DTPA extractable soil Zn concentration and leaf tissues Zn level of apple orchards. The soil analysis for pH, ECₑ (dSm⁻¹) and AB-DTPA extractable Zn concentration of five districts as given in (Table 1) revealed that soil pH in Kalat district was ranged from 8.02 to 8.33, Killah Abdullah from 7.96 to 8.30, Pishin from
8.10 to 8.39, Quetta from 7.81 to 8.47 and Ziarat from 7.50 to 8.42 respectively. While, EC_e was ranged from 1.63 to 4.48 dSm⁻¹ in Kalat, 2.55 to 4.80 dSm⁻¹ in Killa Abdullah, 1.66 to 4.91 dSm⁻¹ in Pishin, 0.51 to 3.31 dSm⁻¹ in Quetta and 0.61 to 4.30 dSm⁻¹ in Ziarat. In case of AB-DTPA extractable soil Zn, the overall Zn concentration in apple orchard soils of Kalat district was ranged from 46.5 to 132.5 mg kg⁻¹, Killa Abdullah from 48.5 to 133.8 mg kg⁻¹, Pishin from 29.4 to 98.3 mg kg⁻¹, Quetta from 24.4 to 97.6 mg kg⁻¹ and Ziarat was from 25.5 to 116.0 mg kg⁻¹ respectively. Similarly, the leaf tissue Zn concentration of apple orchards in five districts are given in (Table 2) revealed that the overall mean of Zn concentration of 30 apple orchards in district Kalat was ranged from 14.6 to 85.1 mg kg⁻¹, Killa Abdullah from 17.6 to 112.2 mg kg⁻¹, Pishin from 11.7 to 120.1 mg kg⁻¹, Quetta from 5.6 to 39.3 mg kg⁻¹ and Ziarat from 5.0 to 55.2 mg kg⁻¹ respectively.

As 30 orchards were grouped into three groups of 10 orchards (locations) in each district and one-way analysis of variance was performed separately on each studied parameter. The result regarding soil pH, EC_e and AB-DTPA extractable Zn as given in (Table 1) showed that statistically pH values were at par in all ten locations of district Kalat, Killa Abdullah, Pishin, Quetta and Ziarat. The higher but statistically at par pH value of 8.26 was recorded in location 2, 9 and 10 with minimum pH of 8.14 in location 5 at Kalat while in Killa Abdullah the higher pH (8.17) was noted in location 3 and minimum pH value of 8.07 was observed in location 8. Similarly, in district Pishin the higher pH (8.35) was found in location 6 and lower pH was 8.17. Whereas, the greater soil pH of 8.40 was recorded in location 7 with minimum pH (8.12) in location 3. The soil chemical reaction or pH in apple orchards at Ziarat indicated maximum pH (8.26) in location 7 and minimum pH (7.83) in location 8. Soil pH plays an important role in the availability of nutrients. The soil pH values in all locations of five districts demonstrated that the soil is alkaline and in such condition the availability of nutrients is one of the constraints for better apple fruit production. While, the electrical conductivity of soil showed statistically at par differences in all locations and in each district that indicate that soil is non-saline with few exceptional cases in district Kalat and Killa Abdullah while the rest of districts manifest EC level in lower range (Table 1). However, AB-DTPA extractable soil Zinc concentration depicted different scenario of all five districts which were statistically highly significant (p<0.05). The apple orchards’ soil Zn concentration at Kalat expressed higher but non-significant level of 112.7 and 112.2 mg kg⁻¹ in location 1 and 2 followed by 104.7 mg kg⁻¹ in location 3 but lower Zn concentration (58.5 mg kg⁻¹) was noted in location 6. Likewise, in district Killa Abdullah, location 5 indicated maximum available Zn concentration (110.5 mg kg⁻¹) and location 6 reflected minimum Zn concentrations (57.4 mg kg⁻¹) while in case of district Pishin, higher Zn concentration (84.5 mg kg⁻¹) was found in location 8 and minimum Zn concentration of 36.0 mg kg⁻¹ in location 4. In district Quetta, location 1 manifested Zn concentration of 77.9 mg kg⁻¹ in location 1 which is statistically higher (p<0.05) over other locations and lower Zn concentration (38.1 mg kg⁻¹) in location 3 whereas location 4, 5, and 8 expressed statistically at par differences in soil Zn level. Though, soil of apple orchards at district Ziarat revealed statistically (p<0.05) higher Zn concentration (101.6 mg kg⁻¹) in location 5 and minimum of 37.7 mg kg⁻¹ Zn concentration in location 4 respectively (Table 1). It demonstrates that the available Zn in soils of various locations of apple orchards across different districts of
Balochistan fluctuates which might be due to differences in soil temperature, organic matter contents, soil texture, Soil supplied Zn, moisture contents, pH and others. One factor is common in most soils of apple orchards that the soil pH falls in alkaline range where nutrient availability is the main constraints. But the majority of soil reflected AB-DTPA extractable Zn in marginal range instead of having high soil pH which could be due to applied Zinc sulfate in these sampled orchards and other Zinc improving factors. The effect of soil temperature on soil mineralization and decomposition of organic matter is reported by Davidson and Janssens [29] seems in line with the results of this study. The calcareous soil exists in arid and semi-arid area and have low organic matter and nitrogen. The calcareous soils are characterized by high pH and lime (calcium carbonate) that make phosphorus unavailable by forming calcium phosphate which is insoluble. The deficiencies of Zn and Fe in such soils are issues in agriculture production including apple and these deficiencies are also known as lime induced chlorosis [30].

Leaf tissue Zn status of apple orchards across five apple growing districts of Balochistan are given in (Table 2). One way analysis of variance of 30 orchards in three groups of ten orchards in each district revealed highly significant (p<0.05) differences in leaf Zn concentration. The results showed that in district Kalat the apple orchard’s leaf Zn concentration (80.76 and 76.00 mg kg\(^{-1}\)) was non-significantly higher in location 10 and 6 and minimum was noted location 5 which was statistically at par with location 8 and 9. Whereas, in district Killa Abdullah higher leaf Zn concentration (104.07 mg kg\(^{-1}\)) was recorded in location 9 immediately followed by Zn concentration of 97.37 mg kg\(^{-1}\) in location 5 and minimum (19.50 mg kg\(^{-1}\)) in location 6 but the other locations expressed at par differences for Zn concentration. While, in district Pishin the non-significantly higher leaf Zn concentration (110.10 and 107.5 mg kg\(^{-1}\)) was observed in location 1 and 2 and minimum Zn concentration (14.33 mg kg\(^{-1}\)) was recorded in location 3 reflecting statistically at par differences for leaf Zn status in location 4-6. Similarly, apple orchards at district Quetta manifested higher leaf Zn concentration of 37.50 mg kg\(^{-1}\) in location 7 followed by 32.40 mg kg\(^{-1}\) Zn in location 5 with lowest Zn status in location 8. Likewise, apple orchards in location 2 and 3 at district Ziarat showed non-significantly higher leaf Zn concentration of 47.57 and 51.0 mg kg\(^{-1}\) and minimum of 6.33 mg kg\(^{-1}\) in location 7. The variability in leaf Zn concentration of apple orchards across apple growing regions of Balochistan depicts spatial fluctuation which is due to change in summer temperature as district Killa Abdullah and plain area of Pishin district have comparatively higher temperature as compared to other three districts during summer but some locations like location 6 in both districts expressed lowest leaf Zn concentration which is due to mountainous and high elevation of the locations and are coolest area of these districts such as Toba Achakzai in Killa Abdullah and Toba Kakari in Pishin that have prominent symptoms of Zn deficiency. Similar narration has reported by Toselli et al. [31] and Weih and Karlsson [32] that plant growth is affected by soil temperature leading to influence root and shoot growth as well as nutrient uptake. The effect of temperature on nutrient uptake is due to changes in water viscosity and transport of nutrients [33, 34]. In surveillance study of fruit orchards for micronutrients conducted by Tariq et al. [35] in Peshawar valley reported deficiencies of micronutrients in various orchards reflecting iron by 45%, Cu 13%, Mn 2% and Zn 17%.
| Location       | Kalat   | Killah Abdullah | Pishin   | Quetta   | Ziarat   |
|----------------|---------|-----------------|----------|----------|----------|
|                | pH      | EC (dSm⁻¹)      | Zn (mg kg⁻¹) | pH      | EC (dSm⁻¹) | Zn (mg kg⁻¹) | pH   | EC (dSm⁻¹) | Zn (mg kg⁻¹) | pH | EC (dSm⁻¹) | Zn (mg kg⁻¹) |
| 1              | 8.18a   | 3.45ab          | 112.7a   | 8.15a    | 3.58a    | 100.1abc   | 8.18b | 2.86a    | 62.7abcd   | 8.13ab | 1.27a   | 77.9a    |
| 2              | 8.26a   | 3.45ab          | 96.9ab   | 8.13a    | 3.98a    | 96.4abc    | 8.27ab | 3.07a    | 77.1ab     | 8.23ab | 1.62a   | 47.2cd   |
| 3              | 8.19a   | 3.10ab          | 104.7a   | 8.17a    | 3.99a    | 102.1ab    | 8.20b  | 2.56a    | 58.7b cde  | 8.12b  | 1.95a   | 38.1d    |
| 4              | 8.19a   | 2.67ab          | 88.5abc  | 8.11a    | 4.00a    | 86.9abcd   | 8.25ab | 3.10a    | 36.0e      | 8.33ab | 1.83a   | 54.8abcd |
| 5              | 8.14a   | 2.85ab          | 112.2a   | 8.11a    | 4.13a    | 110.5a     | 8.20b  | 2.63a    | 40.2de     | 8.32ab | 1.85a   | 64.8abc  |
| 6              | 8.19a   | 2.48b           | 58.5d    | 8.08a    | 3.91a    | 57.4d      | 8.35a  | 3.53a    | 48.8cde    | 8.28ab | 2.23a   | 40.7cd   |
| 7              | 8.18a   | 2.81ab          | 68.5cd   | 8.10a    | 3.67a    | 68.7cd     | 8.30ab | 2.32a    | 62.1abcd   | 8.40a  | 2.25a   | 72.9ab   |
| 8              | 8.19a   | 2.80ab          | 77.1bcd  | 8.07a    | 3.93a    | 77.8bcd    | 8.24ab | 2.66a    | 84.5a      | 8.35ab | 1.93a   | 58.3abcd |
| 9              | 8.26a   | 3.07ab          | 90.9abc  | 8.12a    | 3.72a    | 90.3abc    | 8.24ab | 2.33a    | 70.4abc    | 8.30ab | 1.69a   | 41.2cd   |
| 10             | 8.26a   | 3.94a           | 71.3bcd  | 8.09a    | 3.67a    | 72.8bcd    | 8.17b  | 2.77a    | 65.9abc    | 8.30ab | 1.81a   | 49.5bcd  |
| S.E.±          | 0.07    | 0.69            | 12.80    | 0.078    | 0.639    | 15.18      | 0.066  | 0.621    | 11.23      | 0.136  | 0.746   | 11.67    | 0.288  | 0.812   | 11.16    |
| LSD (p<0.05)   | 0.15    | 1.453           | 26.71    | 0.162    | 1.33     | 31.68      | 0.138  | 1.295    | 23.42      | 0.284  | 1.556   | 24.34    | 0.601  | 1.693   | 23.28    |
| C.V.           | 1.08    | 27.84           | 17.81    | 1.18     | 20.27    | 21.55      | 0.99   | 26.37    | 22.67      | 2.02   | 49.31   | 26.2     | 4.36   | 58.12   | 21.32    |

Table 1. Soil pH, ECₑ (dSm⁻¹) and AB-DTPA extractable zinc concentration (mg kg⁻¹) of apple orchards across 10 different locations of Kalat, Killah Abdullah, Pishin, Quetta and Ziarat districts, Balochistan (Pakistan)

- **LSD (p<0.05)**
- **C.V.**
- **Mean square**
- **Minimum**
- **Maximum**

**Notes:**
- **NS** indicates non-significant differences.
- **N** indicates significance at 0.05 level.
- **s** indicates significance at 0.01 level.
Table 2. Zinc nutrient status of apple orchards in five districts of Balochistan

| Locations | Apple growing districts | Kalat | Killa Abdullah | Pishin | Quetta | Ziarat |
|-----------|-------------------------|-------|---------------|--------|--------|--------|
| 1         |                         | 47.43 cd | 87.53 cd | 110.10 a | 11.03 de | 42.20 b |
| 2         |                         | 65.97 b | 92.60 bc | 107.50 a | 8.73 ef | 47.57 a |
| 3         |                         | 55.10 c | 72.00 f | 14.33 e | 13.30 d | 51.00 a |
| 4         |                         | 38.34 d | 89.83 bcd | 17.73 e | 17.04 c | 12.27 ef |
| 5         |                         | 18.53 e | 97.37 ab | 19.80 e | 32.40 b | 8.47 fg |
| 6         |                         | 76.00 a | 19.50 g | 16.70 e | 16.60 c | 9.70 fg |
| 7         |                         | 44.26 d | 77.17 ef | 44.50 d | 37.50 a | 6.33 g |
| 8         |                         | 19.33 e | 90.10 bcd | 61.13 c | 7.13 f | 15.70 de |
| 9         |                         | 16.60 e | 104.07 a | 87.97 b | 10.23 def | 18.10 d |
| 10        |                         | 80.76 a | 84.43 de | 51.27 d | 18.70 c | 37.57 de |

S.E.± 4.65 3.62 4.32 1.53 1.88

LSD (p<0.05) 9.700 7.55 9.01 3.19 3.93

C.V. 12.32 5.44 9.96 10.84 9.27

Mean square 1661.61** 1675.46** 4251.14** 306.84** 930.34**

Minimum 14.6 17.6 11.7 5.6 5

Maximum 85.1 112.2 120.1 39.3 55.2

Number of apple orchards showing leaf tissue Zn status are illustrated in (Figure 1). Leaf tissue Zn concentration of 15-19 mg kg\(^{-1}\) is validated low, 20-100 mg kg\(^{-1}\) is medium while >100 mg kg\(^{-1}\) is high. In light of these interpretation guidelines, the distribution of 30 apple orchards in each district revealed Zn status in varying degree. It was observed that out of 30 apple orchards in district Kalat 7 orchards were found low in leaf tissue Zn status and 23 orchards were found in medium range but none of the orchard indicated higher leaf Zn concentration. In Killa Abdullah district, two orchards showed lower leaf Zn and two high but 23 orchards manifested leaf Zn status in medium range. In Killa Abdullah district, two orchards showed lower leaf Zn and two high but 23 orchards manifested leaf Zn status in medium range. Likewise, in district Pishin 10 orchards indicated lower leaf Zn concentration, 15 in medium range and 5 in higher range. In case of Quetta district, out of 30 orchards, 22 orchards revealed leaf Zn concentration in low range and 8 in medium range but none of orchard was found in higher leaf Zn status. Whereas, in district Ziarat, 17 apple orchards expressed leaf Zn concentration in low range and 13 were in medium range.

Number of apple orchards indicating AB-DTPA extractable soil Zn status are represented in (Figure 2). The interpretation of the AB-DTPA extractable soil Zn designate that Zn concentration <60 mg kg\(^{-1}\) is considered low, 60-120 mg kg\(^{-1}\) is marginal while >120 mg kg\(^{-1}\) is adequate. Soil Zn in apple orchards in district Kalat was low in 5 orchards, high in 2 and marginal in 23 orchards while in Killa Abdullah, low in 3, marginal in 24 and high in 3 orchards. Similarly, in district Pishin 15 orchards showed low soil Zn and 15 in marginal range while 20 orchards in Quetta expressed low soil Zn and 10 orchards were found in marginal range. However, none of the orchards in Pishin, Quetta and Ziarat showed adequate soil Zn. The variability in the available soil Zn was due to differences in soil physicochemical characteristics and same reasons was reported by Zia et al. [36] that soils vary substantially in pH, EC, moisture content, organic matter and types of minerals in the soil that drive the
availability of nutrients. Further, when soil temperature increases it indirectly enhance root growth performance \[37\] but decrease in soil temperature slow down the growth performance of roots and indirectly lowers nutrients concentration in plant tissue \[38, 39\].

The percentile Zn status of 150 apple orchards in five districts of Balochistan is presented in (Figure 3) as percent of 30 orchards in each district. The overall picture of Zn status of apple orchards showed that 23.3% apple orchards were found Zn deficient in Kalat, 6.7% in Killa Abdullah, 33.3% in Pishin, 73.3% in Quetta and 56.7% in district Ziarat. The Zn deficiencies in these apple orchards need to be removed by applying Zinc sulphate through soil or spray in the dormant period i.e. before buds breaking. If Zn deficiencies were not corrected timely, then these orchards will be succumbed to fungal attack and die back.

Figure 1. Number of apple orchards indicating leaf tissue Zinc status across five districts of Balochistan

Figure 2. Number of apple orchards indicating AB-DTPA extractable soil Zinc status across five districts of Balochistan
Figure 3. Percent leaf Zinc deficiency in apple orchards of five districts of Balochistan

Conclusion
In the light of soil testing and leaf tissue analysis data, it is inferred that most apple orchards of district Kalat, Killa Abdullah, Pishin, Quetta and Ziarat were found deficient in soil and leaf tissue Zn concentration. While, soil of these orchards is alkaline in nature and so make micronutrients particularly Zn unavailable to plants. Consequently, this study suggest that Zinc supplementation to soil of these orchards are needed while the addition of compost under such alkaline soil also necessary which is considered as one of the best management practices for apple orchards.

Authors’ contributions
Conceived and designed the experiments: Hidayatullah, Performed the experiments: Z Khan, Analyzed the data: SAH Agha, Contributed materials/ analysis/ tools: Hidayatullah, R Kethran, Wrote the paper: Hidayatullah, NA Alizai.

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