Türk Bilimsel Derlemeler Dergisi
E-ISSN: 2146-0132 17(1): 1-17, 2024
Derleme Makalesi

INTEGRATED USE OF ORGANIC AND INORGANIC FERTILIZER IN GRAPE (*Vitis vinifera)* PRODUCTION: A REVIEW

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(Received 15th January; accepted 4th May 2024)

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ABSTRACT. Grape *(Vitis Vinifera*) is among the horticultural crops which are consumed as fresh or processed products due to its nutritious importance. High yield and quality grape production are the major focus of grape producers and stakeholders in the value chain. However, nutrient availability is a challenge to reach the targets which cause deficiency of some essential elements for plant uptake. Fertilizer application, either organic or inorganic supports grapevine development accounting for the final yield and quality grape. Organic fertilizer for instance, farmyard, compost and/or vermicompost manure in grapes improves physical and biological properties of the soil by decomposition which makes major nutrients readily available for plant absorption. Supplementation of inorganic fertilizer in grapevines increases macronutrients and micronutrients which enhance plant growth and reduce nutrient deficiencies. Moreover, it provides essential elements required for wine making to produce quality wine. Nevertheless, the application of either organic fertilizer or in organic fertilizer alone has either positive or negative effects in grape production. Therefore, this review discusses the role of organic fertilizer, inorganic fertilizer, essential nutrient elements and the importance of integrated use of organic and inorganic fertilizer as the effective approaches for the production of grape and quality wine.

Keywords; *Berries, Macronutrient, Micronutrient, Yield, Fruit Quality*

ÜZÜM (*Vitis vinifera*) ÜRETİMİNDE ORGANİK VE İNORGANİK GÜBRELERİN ENTEGRE KULLANIMI: BİR İNCELEME

ÖZET. Üzüm (*Vitis vinifera*), besleyici önemi nedeniyle taze veya işlenmiş ürün olarak tüketilen bahçe bitkileri arasında yer almaktadır. Yüksek verimli ve kaliteli üzüm üretimi, üzüm üreticilerinin ve değer zincirindeki paydaşların ana odak noktasıdır. Ancak besin mevcudiyeti, bitki alımı için bazı temel elementlerin eksikliğine neden olan hedeflere ulaşmak için bir zorluktur. Organik veya inorganik gübre uygulaması, üzümün nihai verimini ve kalitesini hesaba katarak asma gelişimini destekler. Organik gübre, örneğin çiftlik avlusu, kompost ve/veya üzümlerdeki solucan humusu gübresi, toprağın fiziksel ve biyolojik özelliklerini, temel besin maddelerinin bitki emilimi için hazır olmasını sağlayan ayrışma yoluyla iyileştirir. Asmalara inorganik gübre ilavesi, bitki gelişimini artıran ve besin eksikliklerini azaltan makro ve mikro besin maddelerini arttırır. Üstelik kaliteli şarap üretmek için şarap yapımında gerekli olan temel unsurları sağlar. Ancak organik gübre veya organik gübrenin tek başına uygulanmasının üzüm üretiminde olumlu ya da olumsuz etkileri bulunmaktadır. Bu nedenle bu derlemede üzüm ve kaliteli şarap üretiminde etkili yaklaşımlar olarak organik gübre, inorganik gübre, temel besin elementleri ve organik ve inorganik gübrelerin entegre kullanımının önemi tartışılmaktadır.

Anahtar kelimeler: *Meyveler, Makro Besin, Mikro Besin, Verim, Meyve Kalitesi*

INTRODUCTION

Grape (*Vitis vinifera L.*) is one of the world's most economically important fruit crops [1], it belongs to the family Vitaceae. Grape is cultivated globally with the major producers being China, Italy and Spain accounting for 11,200,000, 8,149,400 and 6,086,920 metric tons annually respectively [2]. Grape is consumed as fresh or raw materials to make products such as wine, raisins, jam, juice, jelly, grape seed extracts, vinegar and grape oil seeds. Grape activates liver function, digestion and helps to reduce the level of cholesterol and eliminates the uric acid in the body [3]. Moreover, grape contains minerals namely, calcium, potassium, iron, magnesium and vitamin B6, B12 and C which are important for human health [4]. Limited soil nutrients in the vineyards are supplemented by the addition of organic fertilizer or inorganic fertilizer. Excessive nutrients uptake by a plant affects the growth, producing dense canopy and over shades. The organic fertilizer and inorganic fertilizer should be integrated for sustainable nutrient supply in the soil to increase the quantity and quality of grapes. Uses of a blended formulation of fertilizers that includes macro and micronutrients provide sufficient nutrients to plants [5]. However, the application of organic fertilizer represents the conventional standard approach for fertilizing vineyards. This method is characterized by the progressive release of the bound nutrient components during mineralization process. Organic fertilizer makes a significant contribution to protect natural resources which boosts soil organic carbon, soil structure, minimizes the negative environmental effects of inorganic fertilizer, and sustains other organisms in the ecosystem [6, 7]. Furthermore, organic fertilizer assists the soil's bacteria to maintain ecosystem stability and pH balance [8]. Organic fertilizer release nutrients to plants slowly compared to inorganic fertilizers, therefore the integration of organic with inorganic fertilizer is important as they work in tandem to preserve soil fertility and retain high yield and quality grapes [9, 10].

High productivity and quality are a major focus in grape production however, grape production is challenged by a number of factors including climate diversity, weather variability and soil nutrient availability. Thus, this review discusses the potential findings focusing on organic, inorganic fertilizer and the importance of integrated use of organic and inorganic fertilizer for enhancing productivity, quality of grapes and wine.

Organic fertilizer on grape production

Organic fertilizer are natural materials of either plant or animal source, including farmyard manure, green manures, compost manure and vermicompost which works directly as a source of plant nutrients and indirectly influences the physical, biological and chemical properties of soil [11]. Microorganisms decay the organic fertilizer in the soil to make nutrients available for use by plants. Microorganisms improve nutrient mobilization and protect the soil against rain and wind erosion [12]. Moreover, the application of organic fertilizer enhances soil biological activities and the colonization of mycorrhizae that enhances mutuality association between fungi and plants. It also helps to increase soil water holding capacity, improve soil texture, soil structure, organic matter content, and a nutrient rich ecosystem [13]. Nonetheless, it creates a friendly environment for pest infestation and harmful pathogens to plants [14]. Furthermore, due to high variation of nutrient composition in organic fertilizer, there is no accurate application rate which makes it difficult to supply required nutrients to plants. Therefore, research is required to investigate the accurate application rate of different organic fertilizers used in grape production.

Farmyard manure

Farmyard manure is a type of organic fertilizer which is used by the majority of farmers in the tropic and sub-tropic areas in Africa. The fertilizer consists of cow dung, cow urine, waste straw and other dairy wastes depending on the type of livestock kept [15]. The application of farmyard manure helps to supply important nutrients required for grapevine both macronutrients and some of the micro elements [16]. Farmyard manure consists of 0.87% nitrogen, 0.49% phosphorus, 0.77% potassium and 0.42% sulfur of its nutrient composition [17]. In addition, it provides a buffering capacity of the soil pH that controls microbial community composition [18]. The application of farmyard manure enhances soil structure, biomass, soil organic carbon, nitrogen, phosphorus and potassium level and soil chemical characteristics which enhance grape production. According to [19] results reveal that, farmyard manure increased plant pigments and total carbohydrates which in turn improved the quality and ripeness of berries. Furthermore, [20] reported that applying farmyard manure greatly raised the grape berry's total phenolic content.

Compost manure

Compost manure is an organic fertilizer formed by decomposition of organic matter (plant or animal residues) through the activity of microorganisms [21]. Composting is a microbiological process that takes place under aerobic conditions, with an appropriate amount of moisture and temperature, hygienic synthesis of organic wastes into a homogenous and plant available material [22]. Application of compost fertilizer influences the soil properties such as microbial biomass, addition of organic matter which improves root development, yield and fruit quality [23]. In addition, compost manure in grapevines is used as soil amendments to improve soil structure and make good plant growing environments [24].

Vermicompost manure

Vermicompost manure is a bio fertilizer containing most of the essential nutrients with varieties of microbial community for plant growth and development [25]. Vermicompost manure is prepared using organic wastes by the process known as vermicomposting. Vermicomposting is a chemical and biological process that uses microorganisms and earthworms to recycle nutrients [26]. The application of vermicompost manure improves vigor growth, shoot and root development, yield and quality of grapes [27].

Inorganic fertilizer on grapevine

Inorganic fertilizer is a fertilizer which is manufactured artificially containing mineral elements essential for plant uptake [28]. It contains either a single straight nutrient such as nitrogen, phosphorus, potassium, or compound with either one or more macronutrients and micronutrients [29]. The use of inorganic fertilizer provides nutrients to plants quickly in water soluble form which enhances the improvement of growth and development of plants [30] Inorganic fertilizers such as NPK (15:15:15), have a high nutrient concentration and require only a small quantity as recommended for good productivity [31]. Correct amount of inorganic fertilizer improves soil organic matter by increasing root biomass and crop residues [32]. Inorganic fertilizer contains essential nutrients for grapevine including macronutrients and trace elements which enhance growth and development of the plants. Insufficient supplies of inorganic nutrients lower productivity and quality of grape [33]. Therefore, supplementation of in organic fertilizer is required for good outputs in grape production.

Nutrient analysis and management in grapevine

The development of an adequate fertilizer program for managing the nutritional needs of the vineyard necessitates a visual evaluation of the grapevines, growth patterns, nutrient status of plant tissues and soil [34]. An effective nutrient management program for vineyards requires good records of fertilizer, irrigation inputs, vigor assessment, yield, and interpretations of soil and plant tissue test results. Soil analysis is useful in monitoring changes through multiple years, including pH and soil organic matter that can impact nutrient supply in the soil [34]. It is useful in determining potential vineyard planting sites and soil modifications needed before planting. In addition, as grapevines get older, they are able to store larger amounts of particular nutrients to make up for short-term deficiencies in soil supply. For instance, more than 50% of the canopy's nitrogen and phosphorus originated from reserves kept in the roots and trunks of mature, non-irrigated plants [35]. Foliar analysis is more reliable than a soil test for judging the nutrient status of the grapevine while soil test is essential for determination of soil nutrient status prior to vineyard establishment. Plant tissue testing is the preferred method of monitoring the nutritional health of vineyards. A reliable indicator of the nutrients that are available to the plant is the study of the petiole's nutritional composition. The petiole nutrients are compared to the standard indicating insufficient, sufficient, or high quantities of particular components on plant performance [36]. Therefore, tissue test results indicate the nutrient status in grapevines and can be effective in identifying extremes, whether at levels of deficiency or toxicity. Grapevine requires the supplementary application of fertilizer to ensure maximum production and sustainable grape quality. The use of inorganic fertilizers provides good results because of the application of a known and exact amount required and provides an easily available source of both macronutrients and micronutrients for the vine.

Essential elements for grapevine

Plants require a number of nutrient elements for its physiological growth and development which are macronutrients and micronutrients. Grape needs a relatively high number of macronutrients for its plant’s growth parameters [37].

Macronutrients element

Nitrogen

Nitrogen (N) is an essential major nutrient for plants involved in different physiological processes. It is required in a higher amount than the other mineral nutrients and regulates plant vigor and development in the absence of water. N is applied to crops, primarily in the form of nitrate and is taken up by plants as nitrate ions (NO_3) or ammonium ions (NH_4+) from the soil solution, or as gaseous ammonia or gaseous nitrogen (N_2) from the environment [38]. N accounts for about 1.5% of the dry weight (% DW) of grapevine and is found in important metabolites such as proteins, amino acids (AAs), enzymes, DNA, RNA, and chlorophyll. N status in the grapevine affects not only plant vigor and yield, but also grape composition and consequent wine quality [39]. Agronomic practices and fertilization can be altered to meet production targets by monitoring plant N status [40]. The application of N both directly and indirectly affects a variety of grape and must constituents which are beneficial to wine quality and sensory attributes [41]. Thus, modification of N content affects grape composition which has an influence on wine attributes. The concentration of total N and biotin in the must increase when N is applied, when utilizing grapes with low levels of N forms, the must's fermentation may stop as yeasts and bacteria utilize N more than other nutrients after carbon [42]. Inorganic N (diammonium phosphate) must have been used in wineries to increase contents of yeast-assimilable nitrogen (YAN) [42]. The addition of small amounts of ammonium decreases esters and long-chain volatile fatty acids while increasing higher alcohols [43]. High levels of ammonium raise the danger of microbiological instability and the production of carcinogenic compounds such ethyl carbamate and biogenic amines. Moderate levels of YAN favor the balance of desirable and undesirable chemical and sensory characteristics in wine. The application of foliar N during veraison can increase the concentration of nitrogenous compounds of various types in grape and must, such as ammonium N and amino acids, which are essential N nutrient sources for yeasts during the alcoholic fermentation process [44]. Thus, the application of foliar N fertilizer at the veraison stage of grape is the useful approach to ensure a normal fermentation process.

Excess of N on grapevine

A high N status of grapevines may upset the balance of vegetative and reproductive growth, resulting in grapevine overgrowth and a decline in grape quality [45]. Excessive N leads to high vigor, dense canopy, large dark-green leaves, and a long period of vegetative growth. It creates favorable environments for fungal diseases such as downy and powdery mildew, and bunch stem necrosis which ultimately reduce grape yield [46]. The reduced light interception in the fruit zone as a result of higher canopy density delays fruit ripening and lowers the content of total soluble solids (TSS), anthocyanins, terpenes, and total phenols in grapes [47]. The application of N on grapevines should be undertaken with caution because of its contradicting effects on vegetative growth, yield, and chemical composition of the grapes, must and wine.

N deficiency on grapevine

N deficiency results in weak grapevine growth and photosynthesis, short internodes, decreased shoot growth, small-thin, light-green to yellow leaves, poor berry set, reduced long-term bud fruitfulness and yield, reduced grape N content and possibly delayed maturation [48]. N deficit increases phenolic and tannins in the berries which affects wine quality [49]. Low N affects leaves in the grapevine; the symptoms are expressed during the ripening as a result of N translocation from leaves to the berries [50]. Furthermore, leaves wilt and drop under extreme N deficiency during water stress [51]. Vineyards with insufficient N fertilizer have low YAN concentrations (YAN<140mgN/L) in must, which lowers the efficiency of the fermentation process. This leads to high production of alcohol, branched-chain amino acids, branched fatty acid ethyl esters, hydrogen sulfide, and volatile mercaptans with relatively low sensory qualities [52].

Potassium

Potassium (K) is one of the macronutrients required by grapevines. It influences meristem growth, photosynthesis, water uptake, transport of material through xylem and phloem [53]. K has a significant impact in crop resilience to drought, salinity, intense light, or cold and resistance to pests and fungi diseases due to its basic involvement in turgor formation, primary metabolism, and long-distance transport [54]. Leaf analysis during full bloom and berry veraison determines the availability of K in grapes. Nonetheless, high level of K is present free that can be reallocated to growing organs such as berries or kept in reserve organs like branches and roots which make it difficult to quantify actual K in the leaves [55]. K in the leaves is not always related to yield as plants take in more K than they require for metabolism and store it in the cell organelles for later use [56]. Nevertheless, few studies have reported an increase of number and weight of bunches when K fertilizer is combined with N or applied to soil where K availability is below the recommendation [57]. About 50% of total K taken up by the grapevine primarily accumulates in the berries. Its activities in the fruit are related to synthesis reactions and enzymatic activation, directly assisting in fruit maturity, sugar synthesis, and cell turgor maintenance. K is important for transferring of solutes, partition of assimilates, and the synthesis of polyphenols that provide color and scent to fruits due to its mobility in the phloem and xylem [58]. Moreover, K provides vitamin C content, high juice content, uniform ripening of fruits, and resistance to physical damage during transport and storage [58].

Excess K on grapevine

Excessive K supply in the grapevine is undesirable in terms of the sufficient pH and total titratable acidity in the must [59]. The pH shows the ionization capacity of the must and typically not exceeding 3.5, while the total titratable acidity measures the quantity of free acids. Both are related with the stability (oxidation capacity) and quality (organoleptic and visual features) of the must and wine [60]. High K concentration may result in a stoichiometric exchange of the protons of tartaric acid and K, leading to K bitartrate, a salt that precipitates and lowers the organoleptic quality of the wine. This results in less malic acid which is transported to the cytoplasm and a slower rate of breakdown [61]. Because of the increase in pH and decreased tartaric: malic acid ratio, wine is more susceptible to oxidation and microbial damage.

K deficiencies on grapevine

In vineyards with low levels of K, the ability of sink organs to synthesize photosynthates becomes impaired and sugar builds up in the leaves. This restricts the growth of the shoot and the fruit, which causes early leaf fall, poor fruit set, decreased fruitfulness, delayed ripening, and low yield [62]. Low K supply has an impact on fruit set and must pH, therefore, in order to manage grapevine K status, regular monitoring must pH and leaf blade or petiole K concentrations is important [63]. In vineyards, a variety of K fertilizers can be applied in the form of K sulfate (K2SO4), K nitrate (KNO3), K magnesium sulfate, and K chloride (KCl) [64].

Phosphorus

Phosphorus (P) is required for protein synthesis, photosynthesis, respiration, cell membrane, sugar metabolism, energy metabolism, storage and transfer [65]. P nutrient promotes root development and nutrient absorption in plants; it enhances stalk and stem length and resistance to plant diseases [66]. P concentration is useful for making wine that promotes the must's fermentation, which improves the wines organoleptic quality in terms of aroma and taste, however, a grapevine often requires little P [67]. Mono ammonium phosphate (MAP), DAP, and mono Ca phosphate (MCP) are the most widely utilized types of P fertilizers in grape production [68].

P deficiencies in grapevine

Grapevines show deficiency symptoms such as reduced vigor, stunted plant growth, weakened roots, reduced shoot growth, yellowing or reddening of the leaves early leaf loss and basal leaves, reduced fruit set and loose and small clusters under limited phosphorus [69]. Hence, the application of P fertilizers in grapevine leads to increase of leaves, juice, wine anthocyanins and fermentation rate [70].

Calcium

Calcium (Ca) is a macronutrient required by grapevines in a variety of functions either under normal or stressful conditions. Ca is essential for the elongation of cells in both shoots and roots, and tends to interact with the cell walls of the fruit cells, binds pectin, and creates bridges between the pectic acid molecules to keep the fruit firmly in place [71]. Firmness increases shelf life of grapes and less susceptible to disease and insects. Ca deficiency results in chlorosis, necrosis, incomplete flowering, and densely branching shorter roots [72]. Ca fertilizer can be applied as foliar application or drip irrigation in grapevines [73]. It is applied in the soil as gypsum or limestone if the soil test shows deficiency. In addition, acidic soil limestone is added prior to grapevines planting for reducing aluminum toxicity and increasing soil Ca. Application of lime in the soil stimulates phosphatase and peptidase and increases Ca tissue concentration, stiffness of the fruit cell walls and other organs of the grapes [72].

Magnesium

Magnesium (Mg) is a macronutrient that is essential with a number of physiological actions that affect the growth and development of plants. It is the primary component of chlorophyll and initiates enzymatic reactions which assist the generation of carbohydrates in leaves through photosynthesis [74]. Mg nutrient is a cofactor for the activities of several enzymes, including glutathione synthase, carboxylases, protein kinases, phosphatases, RNA polymerases, ATPases and protein synthesis [75]. Insufficiency of Mg nutrient hinder physiological effects of the plants including growth parameters, antioxidant system and accumulation of sugar in the source of leaves [76]. Mg nutrient deficiency lowers the amount of chlorophyll in the leaves; reddish basal leaves, leaf yellowing and early abscission. Notwithstanding, the responses typically rely on the plant species and age. The application of foliar Mg fertilizer during flowering, berry setting, and ripening can reduce Mg deficiency in vines and increase the amount of chlorophyll, fruit quality and improved yield [77].

Sulfur

Sulfur (S) is an essential macronutrient for plants physiological growth and development [78]. It plays a variety of roles in grapes throughout their life cycle such as energy metabolism, synthesis of protein and chlorophyll. S is found in one of its inorganic forms or combined with an organic component. Organic S compounds include sulfur in its reduced or oxidized state. S ensures the homeostasis of vital micronutrients like iron, copper, zinc, and manganese. However, homeostasis between S and iron is one of the most well-known linkages [79]. The abundance and stability of additional flavor, fragrance, and texture components like tannins, phenolic acids, anthocyanins, and aldehydes are influenced by S derived compounds [80]. The symptoms of S deficiency in grapevine appear first at the young parts, weakened grapevine growth, decreased shoot length and chlorosis in leaves.

Micronutrients elements

Micronutrients (trace elements) are essential elements required by plants in small quantities. Micronutrients play a role in plant growth, quality and yield [81]. Plants absorb available micronutrients from the soil reserve or through the addition of fertilizer; however, soil pH is one of the main factors controlling the availability of micronutrients in the soil for plant utilization [82]. Low organic matter content, soil compaction, poor soil aeration, low temperature in the root zone, low nitrogen status level and poor microbiological attributes control the trace nutrients for plant uptake [83].

Iron

The nutrient iron (Fe) is essential for the effective functioning of metabolic activities involving electron transport, such as photosynthesis, respiration and synthesis of chlorophyll [84]. Fe is widely distributed in soils and is produced by complexes of soil organic matter and inorganic minerals. The majority of Fe is found in inorganic compounds, primarily as amorphous Fe, goethite, hematite, and ferrihydrite [85]. The annual loss of Fe in vineyards is quite low, and the overall amount of Fe in the soil does not support the occurrence of Fe deficit, which frequently results from inadequate Fe availability for the grapevines. Shortage of Fe in grapevines results in reduced growth, leaf chlorosis particularly in young leaves and later in old ones associated with changes of the major metabolic pathways, reduction of fruit quality and yield.

Low Fe nutrient in the vineyard is related to the size and age of the vines as well as the fact that Fe is transported over a considerable distance after absorption in order to reach the canopy. On the other hand, alkaline soils are characterized by Fe deficiency, inhibition or suppression of the mechanism that transports Fe from the apoplast to the symplast. The application of foliar Fe fertilizer has been reported to reduce Fe chlorosis in the vineyard and other symptom deficiencies [86].

Zinc

Zinc (Zn) is an important micronutrient for physiological plant growth. It contributes to the synthesis of chlorophyll and is a necessary part of some plant enzymes, such as those which produce auxin [87]. Currently, Zn is known to be an essential component of many dehydrogenases, proteinases, Zn containing enzymes, Zn activated enzymes, protein synthesis, carbohydrate metabolism, synthesis of tryptophan and indoleacetic acid, membrane integrity, and lipid peroxidation [88]. In plants, excess Zn causes morphological, biochemical and physiological disorders. Zn shortages typically manifest in extremely acidic or highly calcareous soils, which causes small bunches to form and internodes decrease. In addition, Zn deficiency causes stunted growth, production of small undersized leaves with mottling between veins, and expanded petiolar sinus, a low fruit set with variable size of the berry [89]. The grapevine phytosanitary materials used to manage diseases are sources of Zn in the grapevines, and the products applied can cause Zn accumulation and alter the distribution of the fractions of these elements in soil. According to [90], foliar zinc sprays in the vineyard are the major effective way in influencing the organoleptic attributes of the fruit and reduce Zn deficiencies in plants. Hence, determining the total Zn level of vineyard soils is the important step in the evaluation of risks to critical soil functions in the vineyard ecosystem.

Manganese

Manganese (Mn) is a micronutrient which is useful in plant nutrition. It is a component of enzymes involved in photosynthesis and superoxide dismutase, a significant antioxidant structure that protects plant cells by lowering free radicals that might harm plant tissue [91]. The availability of Mn nutrient is influenced by the presence of other cation species in soil solution, particularly Mg. Mn nutrient is absorbed by plants in the form of Mn^{2+} ions which are metabolically mediated. This nutrient is a key component of the water-splitting protein called Photosystem II, which is essential for photosynthesis [92]. Mn serves as an electron storage and delivery system for the chlorophyll reaction centers [93]. Mn lessens the effects of water stress and promotes the growth of grapevines under salt, hot, or low temperatures conditions. According to [94] reported that, foliar MnSO4 application can enhance grapevine growth characteristics under water stress and activate water stress defense mechanisms in grapevine, particularly in the Thompson seedless variety.

Integration of organic and inorganic fertilizer in grape production

Use of fertilizer in either organic or inorganic alone can have both beneficial and detrimental impacts on the soil, plant development, and availability of nutrients [95]. Organic fertilizer enhances soil physical and biological processes nonetheless, due to the fact that they are relatively low in nutrients, large amount is needed for plant growth [96]. Inorganic fertilizer is frequently available quickly and contains most of the nutrients required by plants [30]. Nevertheless, consistent application of inorganic fertilizers alone results in the deterioration of soil organic matter, environmental pollution and acidic soil. Mixing organic and inorganic fertilizers increase the amount of nitrogen, phosphorus, and K nutrient that is readily available in the soil and plant uptake [97]. Likewise, the application of both organic and inorganic fertilizers together contains large amounts of nutrients which are available to plants for growth and development [30]. The large quantity of organic matter in an organic fertilizer encourages the activity of soil microbes and enzymes and changes nutrients from their inorganic condition, into a form that crops can readily absorb [98]. Therefore, integrated use of organic manure and inorganic fertilizer is an essential approach for enhancing grape productivity and sustainable soil fertility.

CONCLUSION

The application of fertilizer is very essential in grapevine to increase high yield and quality which are the major focus of grape producers. The use of either organic or inorganic fertilizer supports grapevine growth and development and, provides essential elements which reduce nutrient deficiencies. Organic manure for instance, compost manure, farmyard manure and/or vermicompost manure play a role in improving physical and biological characteristics of soil and provide major nutrients available for plant uptake. Inorganic fertilizer decomposes very quickly after application and is helpful in increasing macronutrients and micronutrients readily available for plant absorption. Foliar application of inorganic fertilizer has increased fermentation process in wine making and improves must and wine quality. Therefore, nutrient management in grapes is important and integrated use of organic and inorganic fertilizer is an effective approach towards achieving soil fertility, environmental conservation and good productivity of grape. Further research needs to be conducted to identify concentration of nutrients available in organic fertilizers based on geographical location, type of livestock and types of grasses and trees used for easy quantification of gap that can be top up by inorganic fertilizers.

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