



Effect of Plant Growth Hormones and Plant Nutrients on different plants: A detailed literature review

Aleena Umar^{1*}, Shafaq Nisar¹, Jihene Ben Ghnia², Mahouachi Wifek³, Meriam Rezgui³ and Muhammad Idrees Jilani¹

¹Department of Chemistry, University of Agriculture, Faisalabad, Pakistan, ²Laboratory of management and valorisation of forest resources, Department of Biology, Faculty of Sciences, University of Tunis. E.I Manar Tunis and ³Institut National de la Recherche en Génie Rural, Eaux et Forêts (INRGREF)- University of Carthage, Ariana, Tunisia,

Abstract

Micronutrients along with macronutrients play a vital role for the better growth of plants and their reduction in the soil becomes major problem of concern for the scientists all over the world. As nutrients are leached out due to extensive cropping, hence a constant and sustained supply of micronutrients and macronutrients required for better quality agriculture products. For the enhancement of global crop production, the development and application of various new types of fertilizers using nanotechnology are one of the potential effective option. Optimized amount of soil micronutrients; copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), manganese chloride ($\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$), boric acid (H_3BO_3), zinc sulphate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) and ammonium molybdate ($\text{NH}_4\text{MoO}_4 \cdot 2\text{H}_2\text{O}$), macronutrients; magnesium sulphate (MgSO_4), potassium nitrate (KNO_3), potassium phosphate (KH_2PO_4), calcium nitrate ($\text{Ca}(\text{NO}_3)_2$) as well as growth hormones can be used for the better crop yield. In the present review different macro and micro nutrients along with growth hormones are discussed in detail.

Key words: Zinc, Basil, Growth hormones, Nutrients, Fertilizers

Full length article *Corresponding Author, e-mail: aleenaumar1512@yahoo.com

1. Introduction

In recent years, in order to convene the emergent necessitate for food, agriculture land per unit area required to attain maximum efficiency and highest quality product. It is known that the nutrition of the plant is the one of the most important factors to control agricultural productivity and quality [1]. Rate of nutrients in the soil affects the quality of yield. The soil will reduce its efficiency due to poor nutrients, as a result, unproductivity in the permanent agriculture land. In this way the producers, combat pests, irrigation, process of agriculture activity and soil fertilization make more resourceful. Chemical fertilizers are reported to have many deleterious effects on human health owing to the presence of lethal and toxic heavy metals in it. These heavy metals also have negative impact on land, soil and water along with humanity. Excessive use of chemical fertilizers has hazardous effect causing pollution and lead to many problems [2] such as greenhouse effect. In addition, the increases in amount of nitrate due to use of nitrogen fertilizer, amount of phosphate due to transportation of phosphorus fertilizer, in rivers and drinking water too much causing human environmental health problems. The extreme use of nitrogen fertilizer contains many carcinogenic Umar et al., 2019

substances such as nitrosamines and their derivatives especially plants such as spinach and lettuce leaves are eaten which leads to harmful accumulation of NO_2 and NO_3 . Unfortunately, increased amounts of gaseous N enter the environment as N_2O to cause greenhouse warming and as NH_3 to shift ecological balances of natural ecosystems [3]. Also, some of the radionuclides and heavy metals such as cadmium and chromium are present in chemical fertilizers in large proportions and causing many harmful environmental problems [4]. To overcome the problem of fertilizer use and increase its economical use, lots of approaches have been made. In-order to overcome these escalating environmental and health issues, globally researchers has put their efforts in synthesizing nano fertilizers. These nano fertilizers have thus revolutionized the shortcomings of commercial fertilizers and have lasting impact on atmosphere and human health. The nano science and nano technology has vast applications in each and every field including agriculture production [2]. The new strategies were introduced to synthesize the nano materials, nano pesticides and nano fertilizers that are not only contributes in increase the product of agriculture land but also reduces the environmental pollution hazardous. Nano

materials are defined as an ingredient containing particles with at least one dimension that approximately measures 1-100 nm. Nano fertilizers (an alternative of ordinary chemical fertilizers) have larger surface area that contributes the more absorption of fertilizer which overcomes the loss of nutrients due to leaching effect. It is also investigated that the micronutrients in nano fertilizers are essential for growth of plants and eventual production of agricultural crops. The fertilizer loss caused by elution and evaporation in the soil system is minimized with the use of nano-sized materials. The nano fertilizer nutrients retain their identity in soil due to their diversity [5]. In addition, nano fertilizers are cost effective and prevent water from toxic pesticides and insecticides. Nano fertilizers are the important tools in agriculture to improve crop growth, yield and quality parameters with increase nutrient use efficiency, reduce wastage of fertilizers and cost of cultivation. They provide more surface area for different metabolic reactions in the plant which increase rate of photosynthesis and produce more dry matter and yield of the crop. It also prevents plant from different biotic and abiotic stress. The nano-fertilizer is the nanomaterials that could serve as macro and micronutrient for plants. Also, it helps as carriers of conventional chemical fertilizers-nanocarriers for efficient utilization of nutrients [6]. Nano particles are generally synthesized by precipitation method using micro and macronutrients in fixed amount. Precipitation is formation of a separable solid substance from a solution, either by converting the substance into an insoluble form or by changing the composition of the solvent.

2. Plant nutrients

2.1. Macro-nutrients

Macronutrients (redox-sensitive agents) play a significant role in plants development. These macronutrients enhance the growth, quality and yield of crops. Due to effective behavior, the macronutrients contribute in various metabolic processes that occurs in plants [7]. Plants require various macronutrients (calcium, magnesium, nitrogen, phosphorous, potassium) in relatively larger amounts, as these are usually present in low concentration in the soil, for better growth of plants [8].

2.1.1. Primary nutrients

Role of Potassium

It also promotes the efficiency of water usage.

Role of Nitrogen

Crucial for the production of amino acids (building blocks of proteins) and is also necessary for the division of plant cell. It is also key component for the growth of plants.

Role of Phosphorus

Phosphorus is necessary for respiration of plants as well as for the process of photosynthesis, energy transfer process, cell division and enlargement. It also improves the quality of fruits, grains and vegetables increasing the growth of plants.

2.1.2. Secondary nutrients

Role of Calcium

Plants utilized the calcium for the formation and continuous division of the cell. It decreases the respiration in plants and helps in the translocation process of photosynthesis from leaves towards the organs of fruiting.

Role of Magnesium

Develops the utilization and mobility of phosphorus in plants and is a fundamental element for the chlorophyll production. It improves the consumption of iron in the plants and influences the maturity uniformity.

Role of Sulphur

Sulphur aids in the development of vitamins and enzymes in plants. As it is the fundamental part of amino acid. It stimulates the formation of nodes on the legumes. It also helps in the production of seeds and is necessary for chlorophyll formation in plants.

2.2. Micro-nutrients

Micronutrients (Zn, Fe, B, Mn, Cu and Mo) are essential for growth of plants and soil production which are present in small quantity in plant tissues with concentration in parts per million (ppm) from 0.15-400ppm. In addition their inadequacy can interrupt the quality and yield of product [9]. According to World Bank statistics, only 5 percent of malnutrition cost of micronutrients is used for domestic purpose [10]. The deficiency of micronutrients in plants is the result of high pH, calcareous nature of soil and depleted organic substance etc. [9].

Role of Nickel

Nickel and cobalt are required in very small amount for the proper growth of plant.

Role of Molybdenum

Molybdenum produces the nutrient reductase which reduces the formation of nitrates into ammonium. It also aids in the node formation on the legumes and is essential for the production of organic phosphates which are important for plants from inorganic phosphates. [11]. It serves as the fundamental part of various enzymes systems. It helps in the production of chlorophyll and also improves the Ca and P availability. [12].

Role of Iron

It facilitates the production of chlorophyll. It acts as oxygen carrier that is involved in the growth of plant and reactions involved in cell division. [13].

Role of Copper

Copper deficiency symptoms appear to be specie specific and often depend on the stage of deficiency. It was regarded as a plant poison. The currently accepted theory behind the mode of action of copper as a fungicide is its non-specific denaturation of sulfhydryl groups of proteins. The copper ion is toxic to all plant cells and must be used in discrete doses or relatively insoluble forms to prevent tissue damage [14].

Role of Chlorine

Chlorine is readily taken up by the plants in the electrically charged form as chloride ion. Although chlorine occurs in plants as chlorinated organic compounds [15]

Role of Boron

Boron is necessary for growth of pollen tubes and pollen grains germination. It is also involved in the formation of cell wall and seeds and promotes the maturity which is necessary for translocation of sugar [16].

Role of Zinc

Zinc is vital for production of chlorophyll and helps in the system of enzymes and of growth hormones. It also facilitates the formation of starch and carbohydrate and of seed formation. Plants also required oxygen, carbon and hydrogen, additionally to the above cited nutrients and are extracted from water and air to make up the bulk of plant weight [17]

3. Plant growth hormones

3.1. Role of Oxalic acid

The effect of oxalic acid on the ripening of banana fruit during storage was studied. Banana fruit were dipped in solution of oxalic acid at two different concentrations (0 (control) and 20 mM). These were stored at room temperature (24 ± 2 °C) and relative humidity was 75-90% respectively. The oxalic acid treatment reduces the respiration rate and ethylene production, and also delayed the decrease in firmness and maximal chlorophyll fluorescence (Fv/Fm) of banana fruit during storage. Moreover, fruit treated with oxalic acid also exhibited higher superoxide dismutase activity and antioxidant ability with lower production of reactive oxygen species at the storage period compared with non-oxalic acid-treated fruit. Overall, the plants treated with the oxalic acid shows inhibiting postharvest ripening of banana and exhibits the potential to store banana at room temperature for commercial application [18]. Litchi fruit treated with two concentrations (2 mM and 4 mM) of oxalic acid and was kept at room temperature to check the effect of oxalic acid on the pericarp browning. Oxalic acid concentration efficiently controls the pericarp browning of litchi fruit during storage. Oxalic acid at concentration of 2mM showed more effectiveness on browning of litchi. [19].

3.2. Role of Salicylic acid

Salicylic acid, a universal plant phenolic compound, is acquiring great attention as a regulator for metabolism and physiological process of plant. It is also involved in both systematic and local plant defense response in plants. It plays a significant role in development and plant growth regulation and immune responses [20]. The deleterious effect of 10^{-2} M salicylic acid on counteracting of NaCl having different concentrations (50, 100 and 150 mM) was applied on maize (*Zea mays* L.). Different parameters (shoot and root lengths, fresh and dry weight and leaf area) were determined to check the effect of SA on the salt tolerance capability of maize. Application of different test

levels NaCl to maize plant has influenced their growth parameters as compared to control plants. Plants treated with salicylic acid exhibited a greater tolerance to salt treatment. Plants treated with salicylic acid exhibited an increase in tolerance to the salt treatment. This increase in salt tolerance was reflected in measured growth parameters (leaf area, fresh and dry weight and length of roots and shoots) as compared with the plants that only received NaCl [20]. The effect of drought stress and spray of salicylic acid was studied at two different concentrations (10^{-4} and 10^{-5} mol/L) on *Zea mays* plants. These concentrations were applied to plants for about 10 days (30–35% field capacity). After 10 days of treatment effect was studied. The SA has more distinct effect at 10^{-4} as compared to 10^{-5} . But the foliar spray at a concentration of 10^{-5} is more effective for adapting the effect of drought stress on maize [21]. The effect of salicylic acid was studied on basil (*Ocimum basilicum*) and marjoram (*Majorana hortensis*) at different concentrations in pot experiment. Salicylic acid increased the fresh weight and dry weight of herbs, amino acids, total carbohydrates, photosynthetic pigments as well as micro-element contents at concentration of 10^{-4} M. Percentage yield of oil was also increased at 10^{-4} in basil plant while at 10^{-3} M in marjoram comparative to control treatment. Major chemical components present in essential oils can be analyzed by GC/MS [22-23]. Results revealed that common components essential oil of *Ocimum basilicum* under all treatments were α -cadinol (9.59 - 4.46%), linalool (46.63 - 43.32%), 1, 8 - cineol (13.20 - 4.43%), methyl eugenol (13.83 - 5.68%) and eugenol (12.64-7.16%). Salicylic acid at concentration of 10^{-4} M increase the production quantity and quality of basil oil to the fragrance and food industries by increasing the percentage of eugenol contents and antioxidant activity in the herb. Instead, the marjoram essential oil contains cis-sabinene hydrate(37.50 - 14.27%), β -caryophyllene (3.82 - 1.76%), terpinen- 4-ol (24.33 - 13.99%), α -terpinene (2.41 - 0.00%), p-cymene (18.21 - 2.29%), sabinene (17.69 - 4.11%), trans-sabinene hydrate (5.45 - 8.19%), γ -terpinene (10.64 - 4.77) in addition to α -terpineol (5.52 - 3.96%). Moreover, SA at 10^{-5} M and 10^{-3} M improves the quality of oil by increasing the level of sabinene component accompanied by decrease in the proportion of cis-sabinene hydrate comparative to controls. It was concluded that SA treatment at concentration of 10^{-4} M might have higher capability to stress and better osmotic adjustment in both species [24].

3.3. Role of Triacontanol

The effect of TRIA was studied, at different concentrations, on crop productivity and crop quality. Hyacinth bean plant was grown in pots and different concentrations (10^{-0} (control), 10^{-8} , 10^{-7} , 10^{-6} and 10^{-5} M) were applied at interval of 15 days. Different parameters like fresh and dry weight, chlorophyll contents and carotenoid contents, carbonic anhydrase content, nitrate

reductase activity, leghemoglobin content and leaf contents were studied at interval of different days (60, 90 and 120 days) after sowing. At higher concentration of 10^{-5} M all the parameters were drastically decreased at all three stages. Seed yield and protein contents were increased at a concentration of 10^{-6} M. TRIA also promotes the activity of tyrosinase in comparison to control plants [25].

3.4. Role of Gibberellic acid

Gibberellic acid (GA), a plant stimulating hormone has a greater effect on the development of plant and the growth, is a tetracyclic di-terpenoid compound. GAs influences the seed germination process, trigger modifications (meristem to shoot growth, juvenile to adult leaf stage, vegetative to flowering, determines sex expression and development of grains) along with interaction with different environmental factors (light, temperature and water). The major bioactive site of GA is stamens which influence the production of male flower and pedicel growth of plant [26]. To elucidate the GA3-priming-induced physiochemical changes responsible for induction of salt tolerance in wheat, three distinct concentrations (100, 150 and 200 mg L⁻¹) of gibberellic acid were applied to two species that are spring wheat (*Triticum aestivum* L.) cultivars, that are MH-97 (salt intolerant) and Inqlab-91 (salt tolerant) were sown in the field treated with 15 dS m⁻¹ NaCl salinity. All these concentrations improve the grain yield in both species. GA3 at a concentration of 150 mg L⁻¹ proved to be more effective in salt tolerant cultivar. Treatment of GA3 (150 mg L⁻¹) decreases the Na⁺ concentrations in both shoots and roots and increase the Ca²⁺ and K⁺ concentrations in roots of both cultivars [27].

3.5. Role of NATCA/AATC and Forchlorfenuron

Apricot being third significant fruit crops of India, acquire great attention in the production point of view. Growth hormones were being used by cultivators to increase the yield to improve their yield parameters. In order to increase yield of apricot (New Castle) 11 different treatments of two growth regulators were applied. The concentration of Forchlorfenuron (CPPU) was taken as 5 and 10 ppm while that of N-acetyl thiazolidine 4-carboxylic acid (NATCA) was 50 and 100 ppm. The combination of both these hormones was also applied to the pink bud and the petal fall stage. Out of the two time of spray of hormones, the petal fall stage was found to be improved. Foliar spray of CPPU at a concentration of 10 ppm increases the size of fruit (29.88 mm), breadth (30.51 mm), weight (16.20 g) and volume (14.93 cc). By keeping all the observations in consideration CPPU at a concentration of 10 ppm in petal fall stage found to be best among all the treatments [28].

3.6. Role of Indole acetic acid (IAA) and indole butyric acid (IBA)

The effect of IBA and IAA (Auxins) concentrations were studied to trees of *Terminalia arjuna* (Roxb.) through

vegetative reproduction through rooting of the stem cuttings. Different concentrations of 0, 500, 1000, 1500 and 2000 ppm of Indole 3-Butyric acid (IBA) and Indole 3- Acetic acid (IAA) were applied to the plants that are planted in the poly bags that are kept under controlled conditions. In comparison to two auxins applied, IBA was the most effective. Out of different concentrations of IBA and IAA, 2000 ppm concentration of IBA was found to be best and attained over 75% of rooting in cuttings. It also triggers greater number of roots, length of root and shoot proliferation, and maximum biomass of shoot and root [29]. The effect of Indole butyric acid (IBA) hormone on the plant of guava (Sufeda) was studied. One-year old healthy branches of guava were grown and wounded by complete removal of 2 inches bark just below the bud for rooting. Wounds were covered with soil media having various concentrations of IBA hormone and were tied from both ends. To maintain the humidity of plant, these were kept in polyethylene bags. Different concentrations of IBA (T1 (50 ppm), T2 (100 ppm), T3 (150 ppm), T4 (200 ppm) and control (T0)) were applied. After application of the treatment, it was concluded that plant treat with 150 ppm IBA was successful and gives the best results [30].

4. Effect of growth hormones

Plant hormones also referred as the photo hormones that have the chief role in healthy development of plant parts and plant body. These hormones act as a functional unit of plants and carry out essential chemical reactions and metabolic processes as well. They have a dominant role in the healthy growth of leaves, stems and flowering as well. These hormones also help the plants to overcome the stress. Plant hormones also known as 'phytohormones' are naturally going on organic matters which implies the vital function in plant growth as well as effects the physiological development (growth, differentiation and stomata movement) at minute concentration [31]. As metabolism supply power and edifice blocks for plant, but only the hormones that control the rapidity of growth of individual parts of plants [32]. In addition, they participate as a controlling agent in reproduction [4]. Plant hormones normalize the augmentation of plants and take place in extremely minute proportion. Growth hormones are most effective for plants because they help to initiate rooting in stem cutting, promote natural detachment of older leaves and fruits and promote flowering in plants.

5. Conclusion

Micronutrients along with macronutrients play a vital role for the better growth of plants and their reduction in the soil becomes major problem of concern for the scientists all over the world. As nutrients are leached out due to extensive cropping, hence a constant and sustained supply of micronutrients and macronutrients required for better quality agriculture products. For the enhancement of global

crop production, the development and application of various new types of fertilizers using nanotechnology are one of the potential effective option. From the above discussion, it is concluded that optimized amount of soil micronutrients; copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), manganese chloride ($\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$), boric acid (H_3BO_3), zinc sulphate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) and ammonium molybdate ($(\text{NH}_4)_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$), macronutrients; magnesium sulphate (MgSO_4), potassium nitrate (KNO_3), potassium phosphate (KH_2PO_4), calcium nitrate ($\text{Ca}(\text{NO}_3)_2$) as well as growth hormones can be used for the better crop yield.

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