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The role of plant extracts in increasing vegetative growth and productivity in plants, biological control, and reducing environmental pollution

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Abstract

The current study reviewed previous research using a range of plant extracts, including garlic, licorice, coconut milk, banana pulp, tomato juice, orange juice, dill oil, caraway, fenugreek, okra, jujube, and extracts from various weed plants such as wheatgrass, barley, mallow, and galangal, as well as volatile and fixed oils from cypress leaves, mint, eucalyptus, myrtle, cypress fruits, bitter orange, anise, date pits, soybeans, and others.

The results showed significant differences between the various treatments. Some plant extracts contributed to increased vegetative and flowering growth and productivity compared to the control group. Furthermore, their addition to the nutrient medium in plant tissue culture stimulated the growth of the cultured plant part. Research also demonstrated that plant extracts can inhibit potato tuber germination. Studies and research have also shown the significant role of plant extracts in controlling insect pests, exhibiting pesticide effects against various insect species, including the southern cowpea beetle.

Keywords: Plant extracts, clean agriculture, sustainability, biological control, biofertilizers

I. INTRODUCTION

The excessive use of chemical fertilizers and pesticides in agriculture, whether added directly to the soil or sprayed on plants, is in fact a form of pollution or poisoning. These substances have immediate or long-term negative effects on human, animal, and plant health, as well as the environment in general. Therefore, a modern trend has emerged among agricultural specialists: adopting biological control and organic nutrition as alternatives to chemical pesticides and fertilizers (Elia et al., 1998). This trend also includes finding natural alternatives from natural compounds that can achieve the same purpose as industrial and chemical materials, but which should generally be less, if not entirely, harmful to humans, living organisms, and the environment (Abo Arab et al., 1998). These compounds can be produced from various parts of the plant (such as roots, stems, leaves, flowers, fruits, seeds, and even pollen). Leaves and roots are considered the primary source of these compounds (Horsley, 1977). Scientific research has shown that many plant extracts influence vegetative and flowering growth, as well as yield, in various plants. This is because these plants contain a number of natural chemical compounds that vary in quantity and type depending on the species, plant parts, growth stage, and environmental conditions. These compounds are typically produced to counter adverse conditions such as environmental stresses like drought, thirst, or pesticide application, or biological stresses like insect infestations and diseases. Research has demonstrated that these compounds have different effects; some inhibit vegetative growth, while others stimulate it (Rice, 1984). Therefore, the search for natural alternatives that are non-toxic to humans and animals, non-polluting, and inexpensive is of paramount importance today. Scientific research has shifted towards abandoning manufactured chemicals and replacing them with alternatives in most fields due to the negative impact of these chemicals on health and the environment (Sadiq et al., 2003). Consequently, the focus has been on using natural plant

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extracts to induce desired changes in a range of plants (Al-Barzanji et al., 2003). After extensive research into the effects of certain plants on other plants through the secretion of what are called allelochemicals, researchers discovered that many plants, when extracted and sprayed on whole plants, parts of plants, or the soil, can reduce the incidence of certain bacterial, fungal, viral, parasitic, and other diseases—acting as pesticides. These extracts also combat physiological disorders, sometimes accompanied by increased vegetative, flowering, and fruiting growth, higher yields, and changes in internal hormonal balance. Therefore, attention turned to plant extracts, and they were experimented with to increase productivity and quality (Nasser, 1997).

II. Review of References

The Effect of Plant Extracts in Tissue Culture

Natural extracts include a group of plant extracts or plant parts. They contain an active ingredient, often unknown, and their addition to the culture medium stimulates the growth of the cultured plant part. Examples include coconut milk or water, banana pulp, tomato and orange juice, yeast extract, etc. All these compounds contain active ingredients. For example, coconut milk contains some cytokinin's, and orange juice contains citric acid, proteins, and a group of amino acids. These compounds, in addition to containing chemically known substances, also contain other, not fully identified, substances that have a beneficial effect on the cultured plant part. Sometimes, natural substances extracted from plants are added to the culture media used in tissue culture (Mohammed and Omar, 1990). Among these substances is coconut milk (CM), as it has been found that the liquid endosperm of coconut (coconut milk) helps in the growth and differentiation of plant parts in many plants, such as the embryos of Datura and Tobacco pith, as it affects cell division due to its content of the natural cytokinin Zeatin. Other extracts have also been used, such as barley extract (ME), yeast extract (YE), tomato juice, and orange juice (Al-Kanani, 1987). Taha (2002) found that adding coconut milk (CM) to the nutrient media used for propagating the native citrus trees Limonium vulgare and Citrus vulgareana had a positive effect on the number and length of branches formed. Jain et al. (1997) reported that callus tissue could be induced from the culture of Limonum cerata on media containing 5-10% CM, in addition to 200 mg/L glutamine. Ibrahim (1971) achieved optimal callus tissue culture from flax cotyledons when cultured on media containing 2 mg/L NAA and 0.05 mg/L kappin with 15% CM. Barley malt extract (ME) is used in tissue culture. A 20% asexual embryo was obtained directly from the endocytic tissue culture of three monoembryonic citrus species—Sindi, lemon, and tangerine at 100-120 days post-inoculation on MS medium supplemented with 500 mg/L ME (Rangan, 1968). A study investigated the effect of species and medium components on the formation of asexual embryos in vitro from immature ova extracted from mature grapefruit. Al-Hafez (2002) stated that the best medium for embryo formation in orange callus, Swinkle stromelo and sour orange is MT medium prepared with 500 mg/L (ME). Edriss and Burger (1984) also indicated the direct formation of adventitious buds on the internodes of Troyer citrange seedlings when these internodes were cultured on MS medium (MS medium with the addition of 50 g/L sucrose and 500 mg/L barley extract) and prepared with 0.5 g/L BA and 0.1 mg/L NAA.

Effect of Plant Extracts on the Physical Characteristics of Potato Tubers

Sprouting is one of the most important factors determining the storability of potato tubers, whether for consumption or seed, due to its impact on the quality value of the tubers. This is because sprouting can lead to increased moisture loss through the growth of sprouts on the tubers (Al-Muhammadi, 2003). Cizkova et al. (2000) observed that carvone, a compound found in dill oil and caraway, is able to inhibit potato tuber sprouting with the same effectiveness as treatment with IPC, isopropyl-3-phenyl carbamate, and CIPC. The effect of this treatment lasted for a long period of 250 days. It is believed that the inhibition of sprout growth is due to the inhibition of the activity of the enzyme hydroxymethylglutaryl-CoA. Oosterhaven et al. (1995) confirm that carvone and monoterpenes, found in high concentrations in caraway and dill seeds, can inhibit sprouting and thus prevent tuber germination. Hartmans and Vries (1996) demonstrated that

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Talent, a compound found in caraway seeds, has a positive effect in preventing potato tuber germination. Carvone is currently used in Europe under the trade name Talent to treat potatoes intended for consumption or seed potatoes to prevent germination during storage. Attempts are also underway to use the compound as a fungicide to control scab and dry rot (Hassan, 1999). Treatment with oils extracted from Lavender, Rosemary, and Sage inhibited the sprouting of potato tubers treated with them. Treatment with the herbs themselves produced a similar effect to treatment with their extracted oils. The inhibitory effect was temporary, as the tubers sprouted normally after the treatment wore off (Vokou et al., 1993). In a study by Al-Muhammadi (2004), using extracts of caraway, fenugreek, okra, and jujube, tubers were dipped for 10 and 20 minutes before being placed in refrigerated storage at 4°C and 80-85% humidity for three months. His study included several characteristics, including the percentage of germination. Statistical analysis showed significant differences between the main treatments using plant extracts. The lowest germination percentage was recorded in the caraway treatment (0.54%) after three months of refrigerated storage, while it was higher in okra (0.68%) and fenugreek (0.73%). The treatment with jujube extract increased the germination percentage to 1.25%. The effect of the caraway treatment continued to reduce the germination percentage after the tubers were transferred to the conditioning system, to the point where it did not exceed 1.60%. In contrast, it reached 1.93% in the okra treatment, 2.22% in the fenugreek treatment, and 1.60% in the jujube treatment. (2.27%) Oosterhaven et al. (1995) indicated that carvone and monoterpenes found in caraway seeds have the potential to inhibit the growth of certain pathogens in refrigerated storage, such as *Fusarium solani* and *Fusarium sulphureum*. Meanwhile, Soliman and Badea (2002) noted that the use of oils extracted from certain medicinal plants has an effect on inhibiting the growth of some fungi. Oils extracted from caraway seeds were found to inhibit the growth of *Fusarium moniliform*, *Aspergillus flavus*, *Aspergillus parasiticus*, and *Aspergillus ochraceus*.

The Effect of Spraying with Plant Extracts on Increasing Growth and Productivity

Scientific research has shown that many plant extracts have an effect on promoting vegetative and flowering growth characteristics and yield traits in many plants. This is because these plants contain a number of natural chemical compounds that vary in quantity and type depending on the species, plant parts, growth stage, and environmental conditions to which they are exposed. These compounds are usually produced to cope with adverse conditions such as environmental stress (e.g., drought, thirst, or treatment with chemical pesticides) or biological stress (e.g., insect infestation and disease) (Mann, 1986). These compounds can be either harmful (inhibitory) to the growth of other organisms or beneficial (stimulating) to them (Rice, 1984). It has been found that extracts from various plant parts possessing toxic properties can be used against certain types of insect pests. Extracts from some plants, such as *Athalia proxima* klug (doptera), can also be used as insecticides or repellents for cruciferous crops after spraying the insects or their host plants with the plant extract. Furthermore, plants treated with these extracts showed no adverse effects (Sudhakar, 1978). Al-Haydar (1996) indicated that extracts from some weed plants (wheatgrass, barley, mallow, and galangal) have a hormonal nature. The high concentrations of barley and galangal extracts stimulated the lengthening of cucumber vines, possibly due to their high content of nutrients such as nitrogen, which in turn encouraged cell elongation. In another study conducted by Al-Haydar (2002) on some weed extracts (halfa grass, safflower, sedge, wild thyme, wild thyme, wild thyme, and cockscomb), using concentrations of 25%, 50%, and 100%, it was found that they significantly increased all studied characteristics of stored potato tubers after three months of storage (germination percentage, apical bud length, number of buds, percentage of weight loss, percentage of spoilage, firmness, percentage of dry matter, specific gravity, percentage of starch, and percentage of total soluble solids). T.S.S. In a test by Al-Jubouri and Al-Haydar (2000a and b) on the effect of different concentrations of hot and cold aqueous extracts of some common summer weeds in Iraq (Dinan, Dahnan, Tartia, Kushiya, Ragheela, and Arf Al-Deek) on the germination and growth of wheat (*Triticum aestivum L.*) and barley (*Hordeum vulgare*), they found that the Ragheela (*Nopodium album*) extract, the concentrations used, and the interaction between them significantly increased all studied characteristics of wheat and barley (germination percentage, lengths, and dry weights of the plumule and radicle). In a study by Hussein (2002) and Al-Alawi (1986), many researchers confirmed the widespread presence of animal sex hormones in plants. However, there are practical difficulties in attempting to isolate these hormones from plants because they are present in very small (trace) quantities, and the methods of separation require a long time and complex equipment. Their

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production in plants is a byproduct of chemical pathways that actively lead to the formation of plant sterols in larger quantities. These sterols are likely used in plant growth and development or to control sexual expression in plants. External treatment of plants with these sex hormones (estrogens) has been shown to stimulate seed germination and growth and to promote flower development. Both estrogens and androgens have been shown to increase sexual expression or the appearance of female characteristics in cucumbers. Research on unidentified estrogenic substances in various plant tissues has focused on their effects in humans. It is possible that some or all plant materials (garlic, oats, barley, rye, coffee, sunflower, parsley, and potato tubers) lack these hormones themselves but contain other compounds that have similar effects to the original hormones. Hussein (2003) indicated that spraying cucumber plants (*Cucumis sativus L.*) with a garlic extract at a concentration of 2.5 cm^3/L of water resulted in a significant increase in plant height, number of branches per plant, number of leaves per plant, and leaf chlorophyll content compared to plants sprayed with distilled water. This treatment also led to earlier flowering of the first female flower and a reduction in the number of days from planting to the start of fruit set. Furthermore, it increased the number of male and female flowers and the percentage of fruit set. Meanwhile, a garlic extract at a concentration of 7.5 cm^3/L resulted in an increase in leaf area and dry weight per plant. Hussein (2003) found that spraying cucumber plants with a licorice root extract at a concentration of 2.5 g/L of water led to a significant increase in vegetative growth characteristics (plant height, number of leaves/plant, and leaf area/plant), flowering characteristics (location of the first female flower, number of days from planting to fruit set, number of male and female flowers, sex ratio, and fruit set ratio), and yield characteristics (first harvest, number of fruits, fruit weight, last harvest, and total yield) compared to the treatment without spraying. Another study demonstrated that spraying with licorice root extract increases the percentage of flowering plants in onions. The extract's behavior was similar to that of gibberellins in stimulating flowering due to its content of the intermediate compound mevalonic acid. It also improves vegetative growth by stimulating enzymes necessary for converting complex compounds into simpler compounds, which are then utilized to provide the plant with the energy needed for growth. This is attributed to the role of terpene compounds in the extract, which stimulate flower bud formation (Al-Marsoumi, 1999). Al-Sahaf and Al-Marsoumi (2001) indicated that spraying onion plants with licorice extract at a concentration of 2.5 g/L of water resulted in a larger leaf area, reduced the number of days from planting to fruit set and flowering compared to not spraying, and produced a higher number of flower spikes. A study on freesia plants found that spraying with licorice extract at a concentration of 2.5 g/plant resulted in greater plant height, a larger number of leaves, a larger leaf area, and a higher relative content. For chlorophyll in the leaves and the greatest number of branches / Fennel brother and the fewest number of days from planting until the first flower opens and the largest diameter of the flower stalk (Al-Rabi'i, 2003).

The Effect of Plant Extracts on Insect Pests

Despite the numerous control methods available, the primary reliance on chemical pesticides has led to problems stemming from their use. Negative effects on humans have emerged due to environmental pollution, which impacts the biotic factors in the ecosystem. Furthermore, insect strains resistant to pesticides have developed, and new, previously unknown pests have appeared. Therefore, those working in pest control have sought to find new or improved methods, both chemical and non-chemical, to limit the spread of insect pests on agricultural crops (Stark et al., 1995). Studies have indicated that plant-based extracts possess high toxicity, comparable to that of manufactured chemical pesticides, and that they decompose rapidly into non-toxic natural substances after a relatively short period of time. It does not leave negative environmental impacts and is highly specialized in its action against one or more insect species (AL-Sharook et al., 1991). The study conducted by Abbas (1998) examined the effects of aqueous and alcoholic extracts of four plants: dill (*Anethum graveolens*), parsley (*Petroselinum hortense*), radish (*Raphanus sativus*), and holly (*Convolvulus arvensis*). The study showed that dill had a strong effect on the larval stage of the rusty red flour beetle, while radish and holly had an effect on the adult stage of the same insect. The biological effects of many plant powders and extracts on insects can be attributed to the primary and secondary compounds present in these plants, which play a significant role in protecting crops and stored materials from insect infestation. This protection can occur through their insecticidal effects. In a study by Al-Jurani (1991), it was found that the petroleum and oily ether extract of the myrtle plant *Myrtus cammunis* had a lethal effect on the larvae and pupae of the khapra insect *Trogoderma granarium* (Everts)

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and the greater wax moth *Galleria mellonela* (L.). The killing rate in the first instar larvae reached 42-100% and 16-78% respectively when using extracts with a concentration of 0.25-1%. Meanwhile, Daoud et al. (1993) stated that the aqueous extract of the tobacco plant *Nicotiana tabacum* was used successfully in controlling many delicate insects such as aphids and thrips because it contains the insect-toxic substance nicotine.

Daoud et al. (1991) reported that the repellent rate ranged from 17% to 73% for the volatile and fixed oils of cypress leaves, mint, eucalyptus, myrtle, cypress fruit, bitter orange, benzoin, date pits, and soybean. Eucalyptus oil was found to be significantly more effective than the other oils in killing and repelling the southern cowpea beetle. Al-Sawah and Daoud (1994) demonstrated that the volatile oil and sesquiterpene compounds isolated from the yarrow plant (*Achellia bieberseteinti Afam*) exhibited a bactericidal effect against three types of economically and medicinally important insects, including the southern cowpea beetle. Meanwhile, Mahdi and Hammoudi (1984) used castor oil, cooking oil, and olive oil against the southern cowpea beetle and found a 100% kill rate for all doses of both olive oil and castor oil.

III. Conclusions

The study showed encouraging results and demonstrated that the extracts from the studied plants have significant effects on improving vegetative growth, flowering, and yield characteristics in various plants. They also possess inhibitory and stimulatory effects. Some extracts showed clear effectiveness in reducing the sprouting rate of potato tubers, thus preserving the desired quality characteristics of tubers marketed for human consumption. The treatments also demonstrated clear effectiveness in reducing the percentage of damage caused by fungal and bacterial diseases in tubers. Furthermore, the study showed that adding plant extracts to nutrient media in tissue culture led to increased growth of the plant part.

The evidence obtained in this study indicates that plant extracts can be safe and inexpensive alternatives to manufactured chemical compounds for various agricultural purposes.

IV. Recommendations

1- Continue conducting studies in this field, preferably using new extracts and methods.

2. The study aims to isolate the active ingredients from the extracts and utilize them in applied research studies to achieve optimal results.

3. Given the effectiveness of the plant extracts used in the study, it is suggested that they could be used as an alternative to plant growth regulators and pesticides for insect pest control.

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