Summary and Conclusion

Extracts from *Echinacea* species are widely used as immunostimulants in the treatment of infections and chronic diseases. Hundreds of herbal and pharmaceutical formulations are now in the markets all around the world. Only in Germany a variety of about 200 echinacea containing drug preparations are on the market, demonstrating not only the therapeutic value, but also the economic importance of this plant.

The plant has been introduced to Egypt, and successfully acclimatized, and it is now used in some herbal drugs released in the local market.

Although there are a plenty of scientific research on the chemistry of this plant, however, very little efforts have been directed towards the agronomical and physiological investigations on this plant.

The present study aimed to throw the light on the role of growth substances, micro-elements and amino acids in the physiological and biochemical characteristics of *Echinacea purpurea* plant. It is aimed to get use of the positive effects of these substances to improve the growth, yield and active ingredients of this plant.

Field work of the present study was carried out during two successive years of 1997-1998 and 1998-1999, in the Experimental Farm belonging to the Faculty of Agriculture, Moshtohor, Zagazig University, Qualyubia Governorate, (50 Km to the North East of Cairo). While all the laboratory investigations were carried out in the Department for Cultivation and Production of Medicinal and Aromatic Plants, National Research Center, Cairo.
Seeds of echinacea were sown in the nursery in middle of January, and transplanted to the open field in middle of April. The seedlings were spaced at 30cm distance on rows of 50cm inbetween, in plots of 2m² each, containing 13 plants. Each treatment was replicated in three plots in a complete randomized design.

The study could be divided into three main experiments covering the following topics:

1-Effects of the growth substances:

Four growth substances were used, i.e. Gibberellic acid (GA3), Kinetin, Indole acetic acid (IAA), and Ethyrel. Each of these substances was applied in four concentrations; 0, 100, 200 and 300ppm.

2. Effects of the micro-elements:

Zinc (Zn), Magnesium (Mg), Manganese (Mn) and Boron (B) were used, each as 0, 50, 100 and 150ppm.

3- Effects of the amino acids:

Aspartic acid, tryptophan, glutamic acid and phenylalanine were applied each as 0, 50, 100 and 150ppm.

In all cases, the treatment was applied as two successive sprays, the first at the vegetative growth stage (45 days after transplanting), and the second spray two months later. Spraying was carried out early in the morning till run off. One liter solution was used for spraying the plants in each plot in the first spray, while two liters were used in the second one.
At the maturity stage, when 70% of the plants bloomed and seeds started to be mature (in September), the following agronomic characters were measured: plant height (overground), root depth, aerial parts dry weight, roots dry weight, number of flowering heads per plant, dry weight of the flowering heads per plant, number of branches per plant and number of suckers per plant.

The measures were taken for 10 plants from each plot, and the mean value was recorded for that replicate.

As well, samples were collected for assessment of their chemical composition; total lipids content, total carbohydrates, soluble sugars, non-soluble sugars, total proteins, phosphorus, potassium, total caffeic acid derivatives, and total and individual alkamides content. A collective sample from each organ of the assessed 10 plants was taken for the chemical investigation in duplicate.

The experiments were repeated exactly in the same way in both 1997-1998 and 1998-1999 seasons, and the collected data were statistically analyzed according to the methods COSTAT. PIF computer program).

Results of the present study could be summarized in the following topics.

1-Effects of the growth substances on the growth and yield parameters of Echinacea plant.

- Gibberellin was the most effective growth substance on the plant height, followed by IAA. Both induced remarkable increase in the length of the aerial parts, while slightly increased the root length.
Regarding the plant weight, IAA was the most effective substance in this regard followed by kinetin. In case of IAA that was rather due to increase in the plant height, but in case of kinetin it was rather due to increase in the dry matter content.

IAA, GA3 and Kn treatments showed the same positive effects on number and weight of the flowering heads.

IAA, GA3 and Kinetin all significantly increased the branching of echinacea plant, with no significant differences among them. However, ethyrel failed to gave such effect.

Kinetin was the best growth substance in increasing the number of suckers produced by echinacea plant.

2-Effects of the micro-elements on the growth and yield parameters of Echinacea plants:

Zn was the most effective element in increasing the plant height, followed by Mg. They rather effected the height of the aerial parts than the roots.

These two elements, also gave the best effect on the whole plant dry weight. Zn expressed its effect on the aerial parts, however, Mg was rather effective on the root weight.

Also, the two elements were the most effective elements on branching and suckers formation of echinacea plant.

Zn, Mg and B positively effected the flowering of echinacea plant in terms of number and weight of the flowering heads.

3-Effects of the amino- acids on the growth and yield
parameters of Echinacea plant:

- Although all the used amino acids enhanced the growth and yield of echinacea plant, however, glutamic acid proved to be the most effective one in increasing the whole plant weight, through its significant effect on the aerial parts weight and more branching of the plant.

- Aspartic acid came in the second rank regarding its positive effect on the whole plant weight. That effect was parallel to significant increase in the root length and weight, as well as, the dry weight of the flowering heads.

- Tryptophan came in the third rank regarding its effects on plant height and weight, as well as, flowering and branching, only the higher doses gave such effects.

- In all cases, the effects were concentrations dependent.

- Phenylalanine was the least effective one on the growth parameters studied. In most cases, the highest level of 150ppm gave negative results.

4-Effects of the growth substances on the chemical constituents of Echinacea purpurea plant:

- Both IAA and ethyrel were effective in increasing the lipids content in the aerial parts and flowering heads rather than the roots. On the contrary, both GA3 and Kinetin rather increased the lipids content of the roots.

- It appeared to be differences in behavior between the plant organs in their response to the applied growth substances.
The increase in the lipids content due to IAA and GA3 treatments was accompanied with increase in the alkamides accumulation. In case of IAA, the lipids rather accumulated in the roots, while in case of GA3, they rather accumulated in the overground organs.

The applied treatments did not influence the proportional content of the individual alkamides, so the alkamides spectrum remain the same characteristic spectrum for echinacea plant. However, the minor fluctuations in the relative percentage in the major alkamides explain the synthetic relationship among these alkamides from the same precursor.

GA3 and kinetin were the most effective substances used in increasing the carbohydrates, phosphorus and potassium in the plant organs. That was accompanied with increased contents of caffeic acid derivatives in these organs.

IAA enhanced the accumulation of protein and lipids together with the alkamides content in all the plant organs. While, kinetin enhanced the accumulation of protein and carbohydrates together with the caffeic acid derivatives.

5-Effects of the micro-elements on the chemical constituents of *Echinacea purpurea* plant:

All the used micro-elements gave positive effects on the chemical constituents under investigation in the plant organs with variable degrees.

Zn and Mg were the best in increasing the lipids content, that was accompanied with similar increase in the alkamides content of all the plant organs.
Both Mg and B were the most effective ones in increasing the protein and phosphorus contents, and that was accompanied with similar increase in the content of caffeic acid derivatives. In case of Mg, that took place in all the plant organs, however, in case of B, that rather took place in the overground organs. 

Both Zn and Mn were the most effective ones in increasing the total carbohydrates especially the soluble fraction. In case of Zn that was accompanied with increase in the alkamides content of all plant organs.

6-Effects of the amino acids on the chemical constituents of Echinacea purpurea plant:

Aspartic acid was the most effective amino acid in increasing the lipids in the overground plant organs, as well as, the alkamides content in all the plant organs including the roots.

Both aspartic and glutamic acids were the most effective ones in increasing the alkamides content in the plant organs.

Both aspartic acid and phenylalanine were the most effective amino acids applied regarding their effect on the caffeic acid content in all the plant organs. In case of aspartic acid, that was accompanied with remarkable increase in the total carbohydrates, non-soluble sugars, P and K. While, in case of phenylalanine, the effect was rather on the P and K contents, in the flowering heads and roots, respectively.

The obtained data showed that both aspartic acid and phenylalanine were rather incorporated in the synthesis of caffeic acid derivatives. On the contrary, glutamic and tryptophan were rather directed towards the protein synthesis, they were the most effective ones in this regard.
Both aspartic acid and tryptophan were rather effective in increasing the total carbohydrates, non-soluble sugars and P content in all plant organs. In case of aspartic acid these major constituents, together with high lipids content were converted to alkamides and caffeic acid derivatives. However, in case of tryptophan, the plant rather continued to accumulate carbohydrates, lipids and proteins. In both cases, a high phosphorus content was parallel to the high carbohydrates content.

**Recommendations:**

- Finally it should be concluded that, it is the balance or interaction among the individuals of each of these groups; i.e. growth substances, micro-elements or amino acids, rather than a summation of their individual actions that must provide the key to the plant development and composition.
- IAA and GA3 both at 200 ppm proved to be effective substances in increasing the growth, yield and active ingredients of *Echinacea purpurea* plant.
- Mg at 150 ppm and Zn at lower levels (50 or 100 ppm) enhanced the growth and yield of Echinacea plant, as well as, the accumulation of the active ingredients in the plant organs.
- Aspartic acid at 50 ppm has a universe positive effect on both the growth and yield, as well as, the content of active ingredients of echinacea. Other amino acids used, were effective on either the growth or the chemical constituents.
- Due to the debate about the use of the growth regulator and their side effects, therefore it is advisable from the practical point of view to
rely rather on the micro-elements or amino acids as tools to improve the yield and composition of *Echinacea purpurea* plant.