

EFFECTS OF PHYTOHORMONES ON CARBOHYDRATE AND NITROGEN METABOLISM OF SOME DROUGHT STRESSED CROP PLANTS

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SUMMARY: This work was conducted to study the effects of exogenously applied phytohormones (gibberellic acid, indole acetic acid and kinetin) on water-stressed maize, cowpea and broad bean plants. It was found that drought adversely-affected the synthesis and translocation of carbohydrates as well as the nitrogenous compounds which resulted particularly in an accumulation of the amino acid proline. Application of phytohormones resulted in a considerable increase in carbohydrates and total nitrogen contents. On the other hand proline accumulation was considerably retarded whatever the plant organ analyzed, the plant species tested and the level of stress or phytohormone used.

Key Words: Drought, phytohormones carbohydrates, Nitrogen, Zea mays, Vigna sinensis, Vicia faba.

INTRODUCTION

The adverse effects of drought on plant metabolism were repeatedly studied. These include some disturbances in carbohydrate metabolism (20) as well as in nitrogen metabolism (8, 26), particularly proline accumulation (1, 22).

It is generally accepted that treatments with phytohormones may lead to regulation of the plant metabolism and consequently plant performance (13, 14, 15). Similarly the application of phytohormones to variously stressed plants may lead to counteraction of the adverse effects exerted by stress conditions (9).

In view of these findings, it was of interest to test whether the exogenous treatments of phytohormones (gibberellic acid, indole acetic acid or kinetin) can counteract the adverse effects of drought on plants. Thus, the present work was carried out to study the interactive effects of IAA, GA₃ and kinetin on carbohydrate and nitrogen metabolism of drought-stressed maize, cowpea and broad bean plants.

MATERIALS AND METHODS

Grains of maize (*Zea mays*) and seeds of cowpea (*Vigna sinensis*) and broad bean (*Vicia faba*) were sown in plastic pats containing 2 kg air-dried soil. The pots were then watered to the desired soil moisture content (100 %, 90%, 70%, 50% and 30 %). The plants were left to grow under these variable soil moisture contents until having two foliage leaves. These plants were then sprayed with an aqueous solution (50 ppm) of any of the three phytohormones (IAA, GA₃ or kinetin). Some plants were left unsprayed and regarded as reference plants. After the experimental periods, some chemical changes were followed.

The anthrone sulphuric acid method (7) was used for determination of carbohydrates. For determination of nitrogen contents, the micro-kjeldhal technique was employed. Free proline was determined according to the method of Bates *et al* (2). Data were analysed statistically and the least significant difference were calculated.

RESULT AND DISCUSSION

The contents of total carbohydrates (mg gm⁻¹. dry weight) tended, in most cases, to decrease with the decrease of moisture level in the different organs of the variously treated plants. However, in broad bean this decrease was more obvious (Figures 1, 2 and 3). These

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Figure 1: Interactive effects of soil moisture contents and phytohormonal treatments on carbohydrate contents of maize plants.

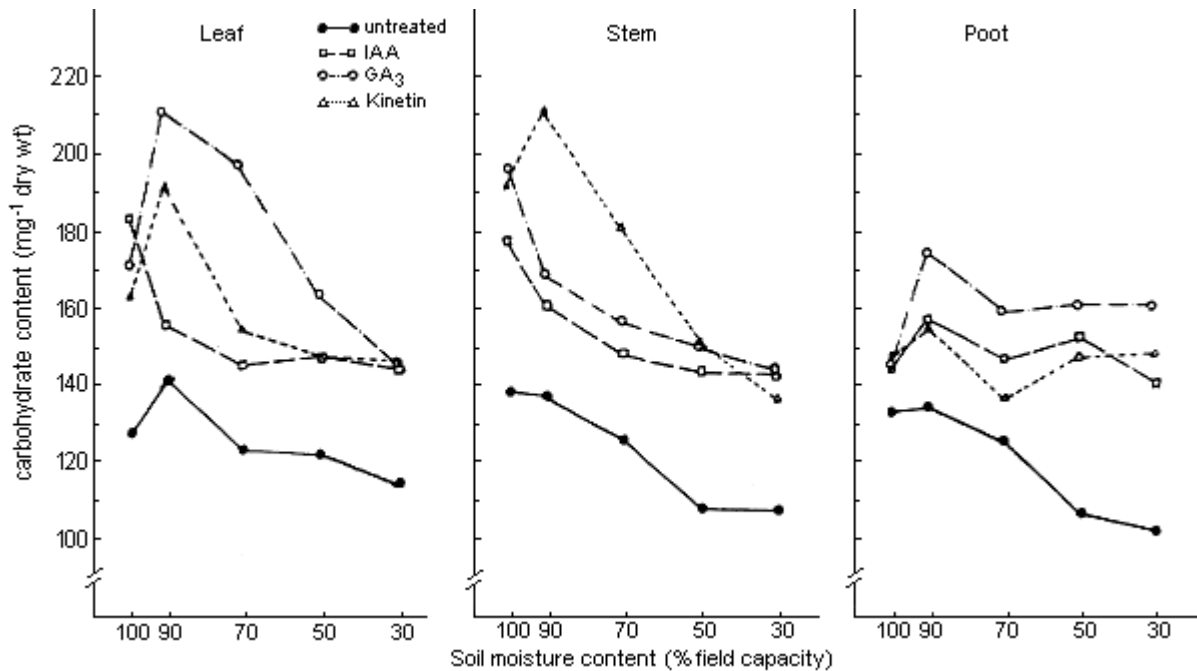
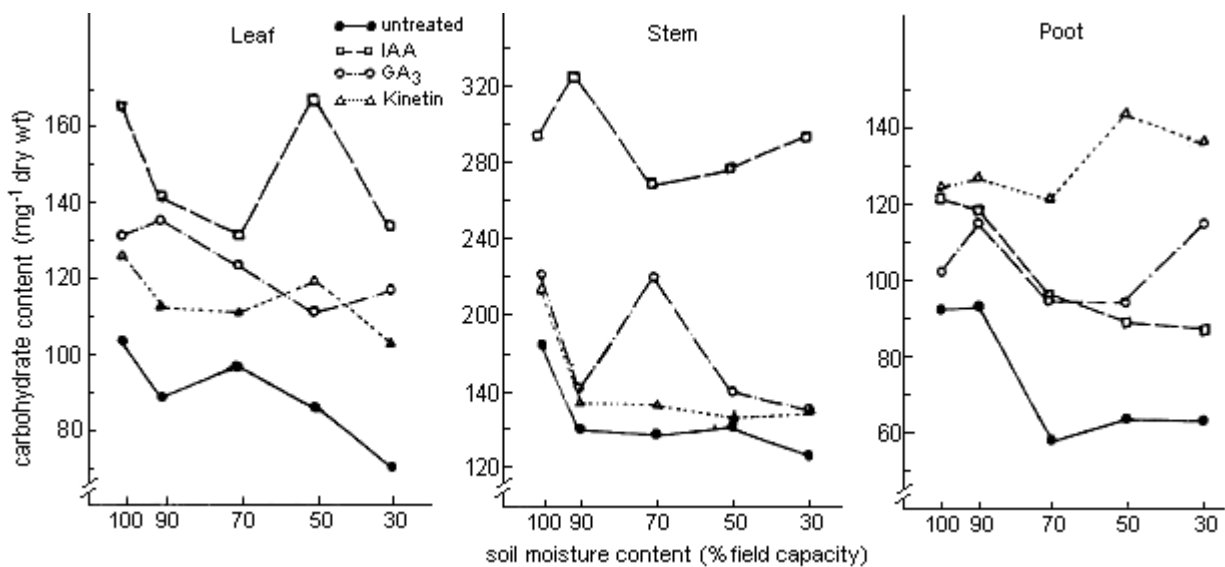


Figure 2: Interactive effects of soil moisture contents and phytohormonal treatments on carbohydrate of cowpea plants.



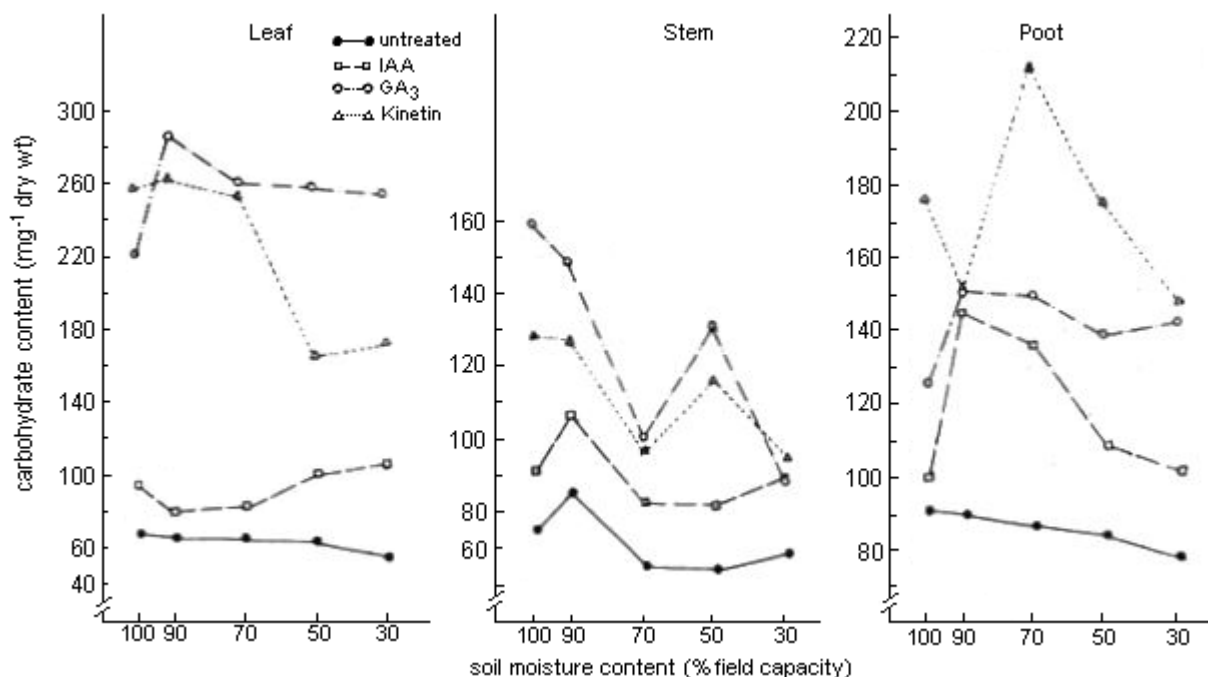
results are in agreement with those obtained by some other authors (25).

Hormonal treatments (IAA, GA₃ or kinetin), resulted in a highly significant increase in carbohydrate contents, whatever the moisture content used, plant tested and the organ analysed. This stimulatory effect exerted by the three phytohormones may be attributed to the obvious increase in leaf area as well as in the number of stomata

(Part I) which consequently lead to the increase in photo synthetic activity. Such results were also obtained by Ikuma and Thimman (11), El-Deep (6) working on the interactive effect of salinity and phytohormones.

The nitrogen fractions of the main plant parts of the variously treated maize, cowpea and broad bean plants exhibited markedly variable contents which consequently affected the total nitrogen content (Figures 4, 5 and 6). In

Figure 3: Interactive effects of soil moisture contents and phytohormonal treatments on carbohydrate contents of broad bean plants.



this respect, maize, cowpea and broad bean leaves exhibited, in most cases, a limited accumulation of total nitrogen contents. However, in cowpea and broad bean stems and maize roots, the contents of insoluble nitrogen were generally elevated with the decrease of soil moisture content. This could be attributed to the depression of NO₃⁻ delivery via the xylem to shoots and of NO₃⁻ reduction in the leaves (18, 21). Moreover, Kembel and Macpherson (16) stated that, drought stress could result in proteolysis and interruption of protein synthesis.

Phytohormonal application resulted in an obvious increase in the contents of nitrogen fractions (soluble, in soluble and total) in the different organs of the water stressed maize, cowpea and broad bean plants. This may be due to activation of protein synthesis exerted by the exogenous phytohormone treatment (3).

Proline, which is generally thought to counteract the injury exerted by water stress (10) was progressively accumulated in the main plant organs (leaves, stems and roots) with the decrease in moisture content (Figures 7, 8 and 9). Similar results were obtained by some other authors (5,23,24). They demonstrated that free proline accumulated in different plant species as a result of water stress induced either by addition of salts or by decrease of moisture content. Barnett and Naylor (1) and Boggess *et al.* (4) reported that, within the leaves of many plants sub-

jected to moderate or severe water stress, one striking change in nitrogen metabolism is the accumulation of free proline as a result of *de novo* synthesis from glutamic acid. However, the physiological significance of proline accumulation in plant tissues subjected to water stress is still unclear and may differ with different species. In this work the increase in free proline in the three main organs of the experimental plants goes just opposite to that of total protein nitrogen. This is in accordance with the results obtained by some other authors (4, 19). Thus, the accumulated proline could be considered as a storage nitrogen compound (1) and/or a metabolic adaptation product (23).

After spraying with phytohormones, the accumulation of proline was considerably retarded, whatever the plant organ analysed, the plant species tested and the level of stress or phytohormone used (12). This retardation may lead to the conclusion that each of the three phytohormones (IAA, GA₃ or kinetin) used could alleviate the adverse effects of water stress. If proline accumulation is considered as an indication of stress injury, thus it can be said that, the exogenously applied growth hormones seem either to protect the plant against water stress injury and consequently the synthesis of proline is retarded, and/or to play a specific role in proline transformations to other growth constituents.

Figure 4: Interactive effects of soil moisture contents and phytohormonal treatments on carbohydrate contents of maize plants.

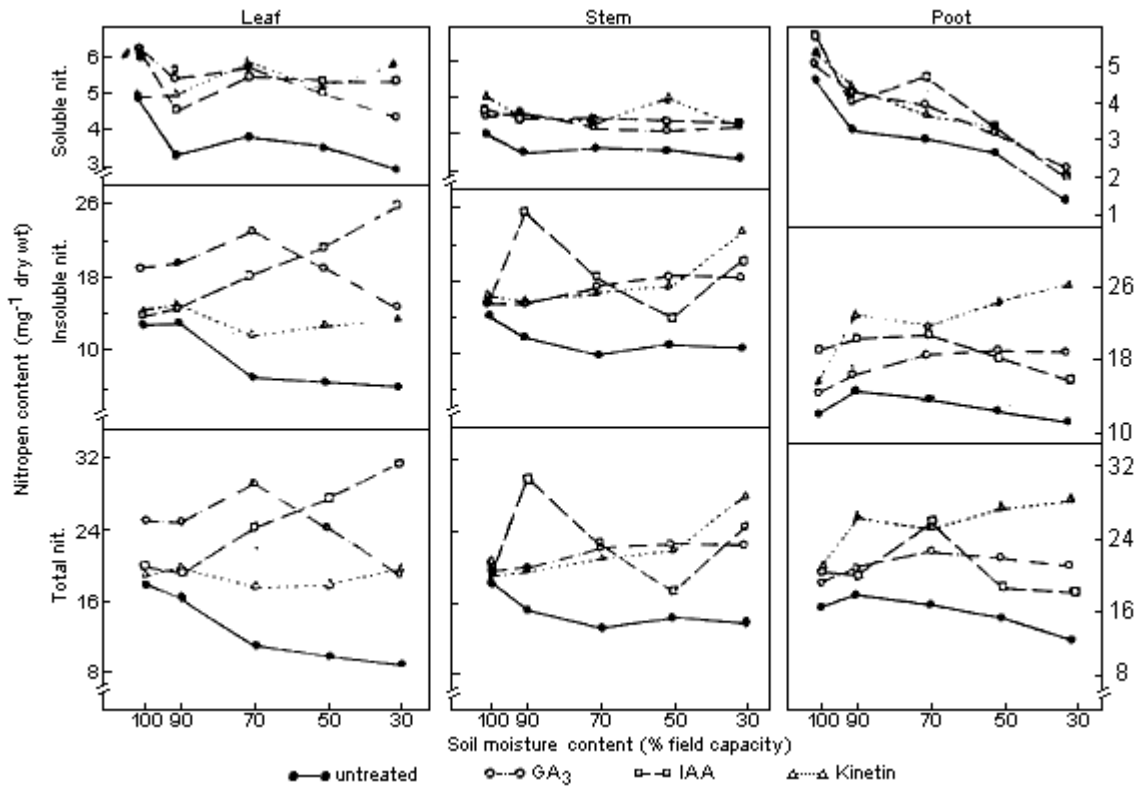


Figure 5: Interactive effects of soil moisture contents and phytohormonal treatments on nitrogen contents of cowpea plants.

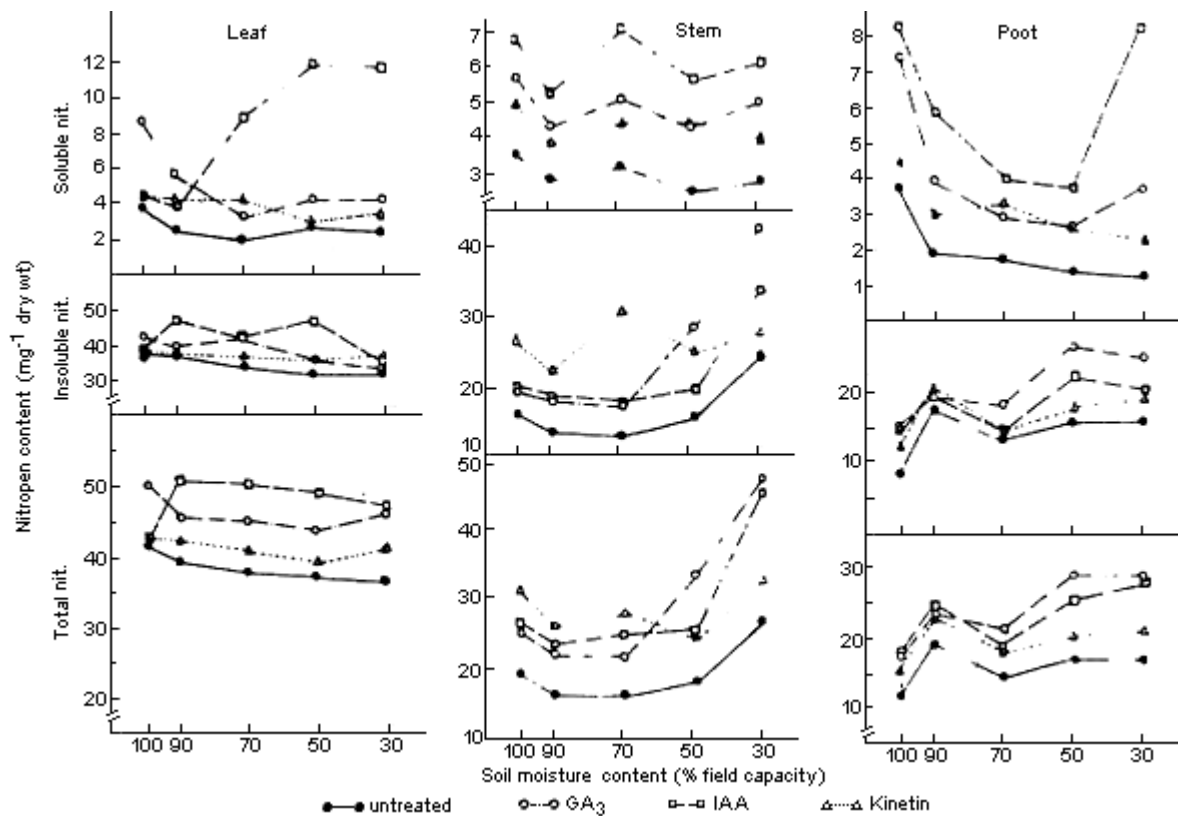


Figure 6: Interactive effects of soil moisture contents and phytohormonal treatments on nitrogen contents of broad bean plants.

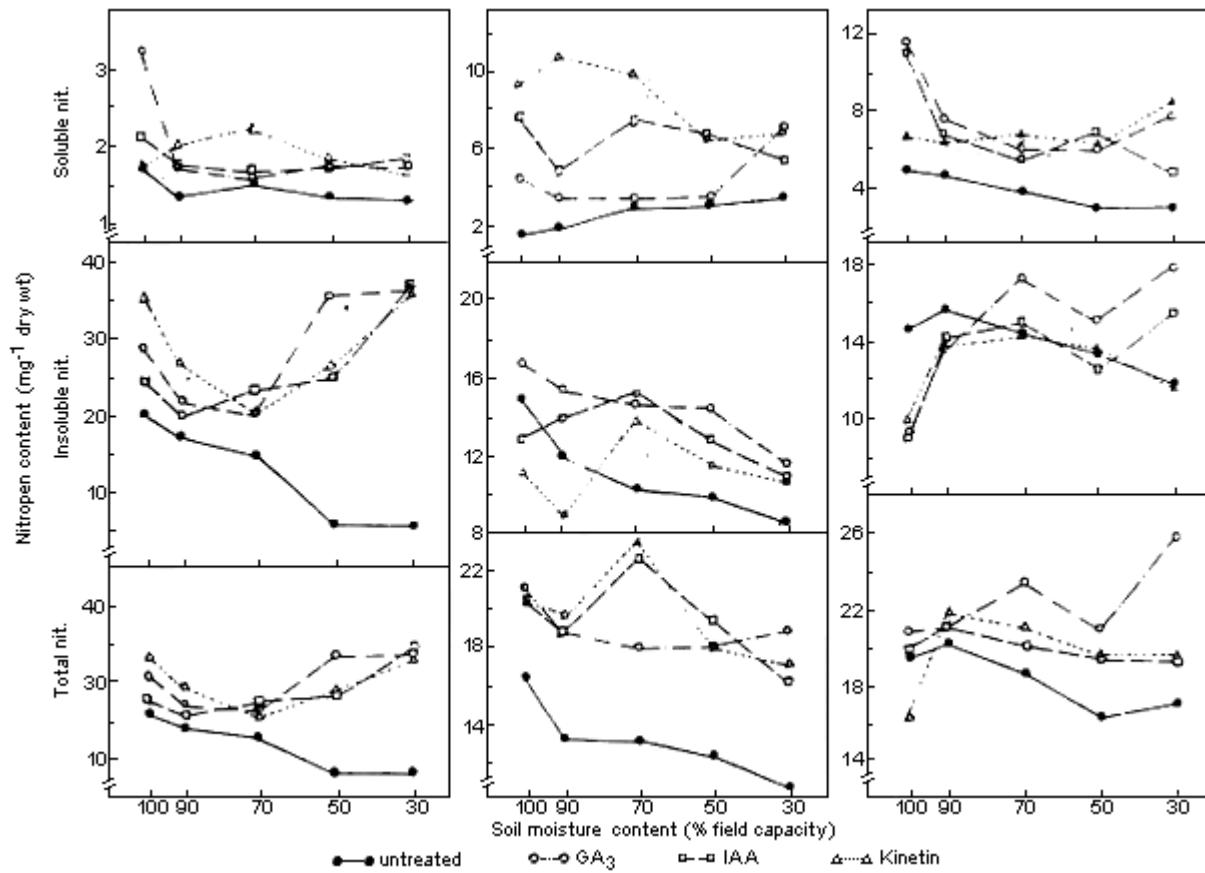


Figure 7: Interactive effects of soil moisture contents and phytohormonal treatments on proline content of maize plants.

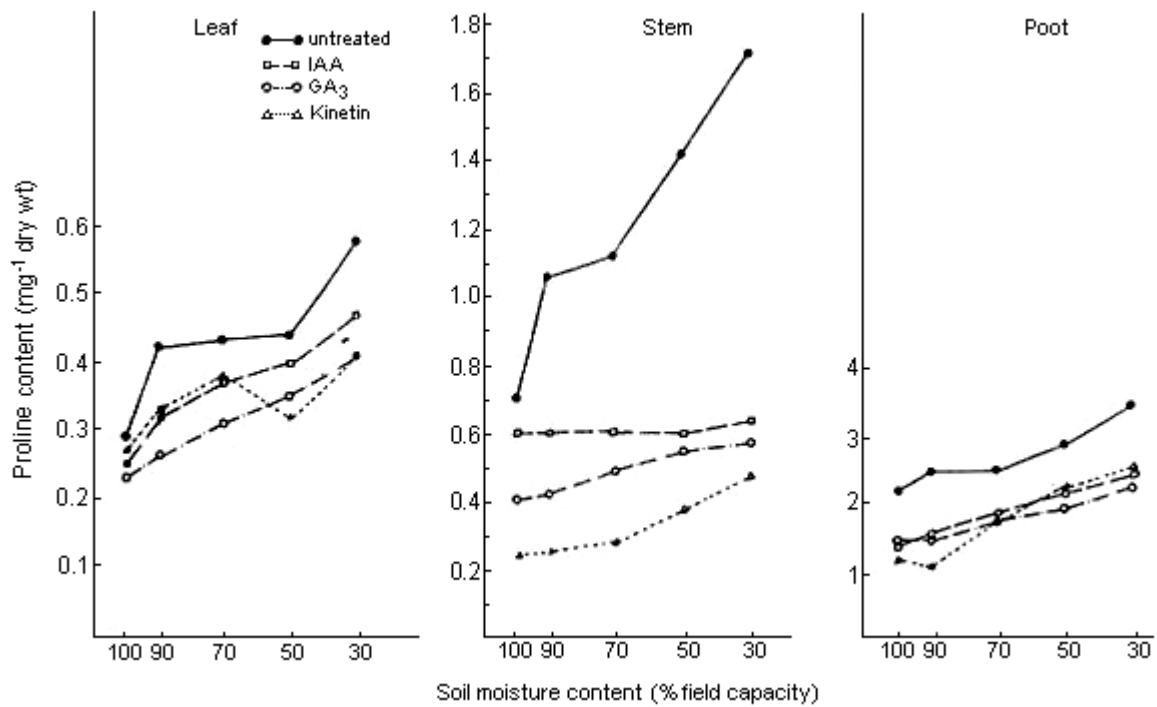


Figure 8: Interactive effects of soil moisture contents and phytohormonal treatments on proline content of cowpea plants.

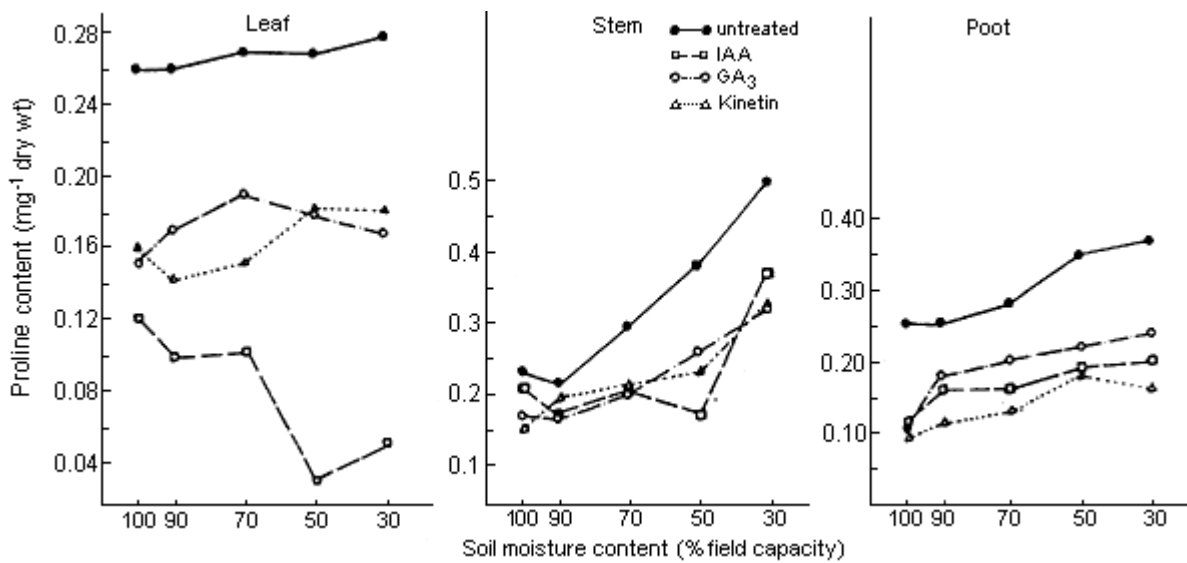
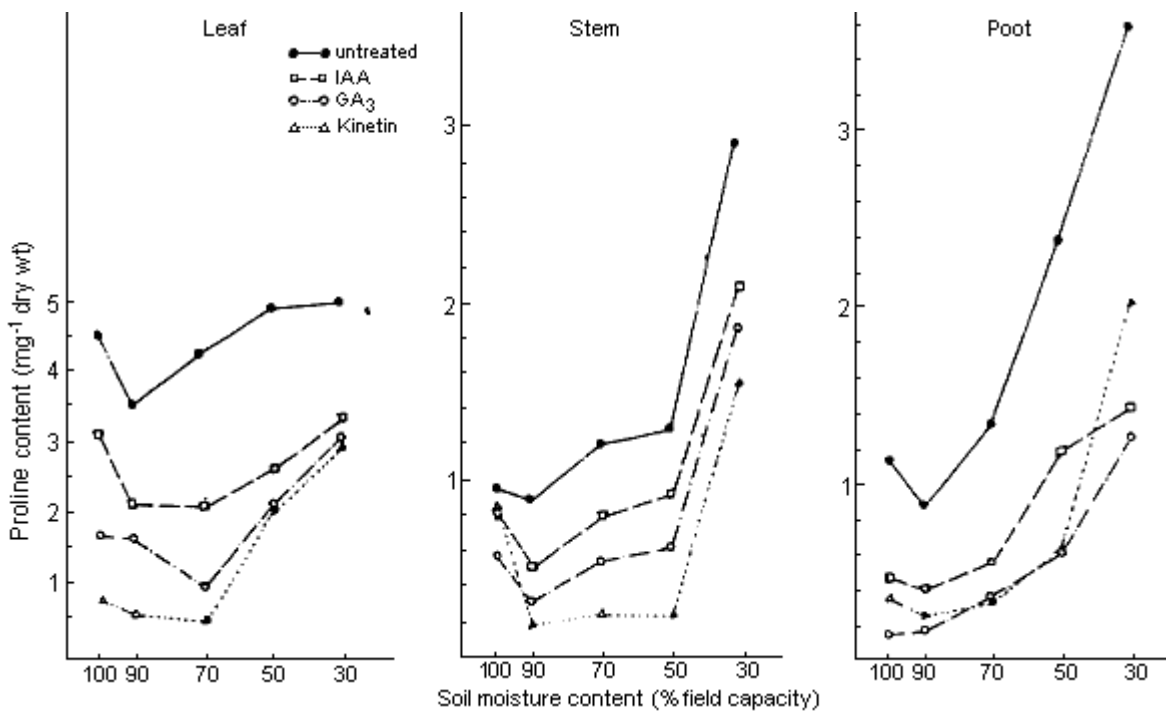


Figure 9: Interactive effect of soil moisture contents and phytohormonal treatments on proline content of broad bean plants.



Generally, it can be said that the exogenous phytohormone treatments might counteract the negative effects of drought stress exerted on carbohydrate and nitrogen metabolism, which consequently could promote the whole plant growth.

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