FURTHER STUDIES ON THE METABOLIC EFFECTS OF CHROMIUM SALTS ON DATURA STRAMONIUM

THESIS

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MONA ELEIWA

THIS THESIS HAS NOT BEEN PREVIOUSLY SUBMITTED FOR ANY DEGREE AT THIS OR ANY OTHER UNIVERSITY.

THE REFERENCES IN THE TEXT WILL SHOW SPECIFICALLY THE EXTENT TO WHICH I HAVE AVAILED MY-SELF OF THE WORK OF OTHE AUTHERS.

MONA MOHAMED EL-HOSEINY IBRHAIM ELEIWA

DEDICATION

To those who stood beside me

To those who encouraged me to carry on research

To the love, affection and caress

I DEVOTE MY SELF

AND

MY THESIS

TO THEM

TO MY PARENTS

AND

MY SONS

C O N T E N T S

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ARABIC SUMMARY.

P R E F A C E

In a previous investigation, Kord (1978) sprayed 45 days old Datura stramonium plants with 5, 10 or 50 x 10^{-5}M of either potassium chromate, ammonium dichromate or chromic chloride, three times within consecutive three weeks. She noticed stunting of growth, reduction in number of leaves, leaf area, fresh and dry weight. Such phenomena were partially alleviated with increased concentration of anionic chromium and/or number of sprays, whereas cationic chromium ion was stimulatory.

Inspite of the inhibitory effects of chromium (VI) compared with chromium (III) on alkaloid content per plant or unit leaf area, yet the percentage alkaloid, following chromium (VI) treatment was higher than chromium (III); the former increased while the latter decreased with increased number of sprays.

In this endeavour, the seed yield of this experiment was sown in normal soils while untreated seeds were sown in soils to which was added the same concentrations of chromium salts in order to find out whether or not the difference in treatment might affect the response of the plant to the chromium salts. In the meantime, re-sowing of seed yield might give a clue to whether or not the previously reported results by Kord (1978) were persistant.

PART I

INTRODUCTION

A- HISTORICAL REVIEW.

B- MATERIAL AND METHODS.

PART I

I N T R O D U C T I O N

A- HISTORICAL REVIEW

Inspite of the fact that pollution with heavy metals received a great attention within the last few decades, yet chromium received a little attention in comparison with other metals studied (viz. lead, mercury, zinc or tin).

Chromium has not been yet introduced into the biocide industry. Thus, it plays a little or no role in the economy of cultivated soils, except being considered as a trace nutrient element.

According to the American Standards Association, the maximum permissible dose of chromium must not exceed o.lmg/lm air. As a water pollutant, hexavalent chromium could be removed through adsorption by calcinated coke (Huang and Wu, 1975), whereas divalent chromate and dichromate apparently had a slight affinity towards the calcium surface and consequently could not be removed.

The health hazards, reported for chromium, include chronic bronchitis, tubercular lesions, ulcers and in few cases neck dermatitis (Krishna et al., 1976; Hill et al., 1979). Being air pollutant, it also causes carcinogenic hazards (Paradoupiaou et al., 1976). It alleviated death if administered to mice as chromium chloride, one hour before challenging them with Salmonella typhosa (Snyder et al., 1977). Chromium chloride markedly reduced several of the biologic activities of Salmonella lipopolysaccharides including toxicity

(Snyder et al., 1978). Still it enters in the base metal alloys used in dentistry - to prevent its corrosion by saliva (Espevik, 1978).

It is interesting to note that chromium is one of the heavy metals reported in the human body of Japanese people (Sumino et al., 1975). It showed higher concentrations in tissues exposed to environment and accumulated in larger levels in males than in females. Punsar and Karvonen (1979) postulated that coronary heart disease may be associated with low levels of magnesium and chromium in the drinking water of the eastern areas of Finland.

Chromium received a great attention in the last decades, because of its widespread application in inudstrial and domestic products irrespective of the high toxicity of several of its chemical forms. Industrial production and handling of certain Cr (VI) products are associated with respiratory injury, carcinogenesis particularly in lungs,skin ulceration and induction of allergic chromium dermatitis (Burrows, 1978). Land dumping of wastes from industrial Cr (VI) production and electroplating operations are mainly responsible for ground-water contamination (Burows, 1978). Discharge of Cr (VI) into streams and rivers or leaching from sludge by flowing sea water caused damage to aquatic ecosystems.

Such dumping of sewage sludge in coastal tropical waters can lead to uptake and concentration of toxic trace metals by members of a turtle grass community (Montgomery and Price, 1979). Wagemann (1978) pointed out that barium, chromium, iron and copper had a controlling influence on total dissolved arsenic in fresh water systems.

Sharkhnazqrov et al., (1974) pointed out that workers in potassium dichromate industry (upto 5 years service) had a high glycogen, acid and alkaline phosphatase activity in their leucocytes. Those working more than 10 years were short of glycogen in their leucocytes and both phosphatases were inhibited. Apart from the lowered dynamic values of spirometry, the workers dealing with chromium electro-plating are subject to development of obstructive respiratory syndrome (Bovet et al., 1977).

In his report; Jauorski (1976) mentioned that most of Cr (III), present in water, is adsorbed on particulate matter whereas Cr (VI) remains in solution where it is a powerful oxidising agent. Cr (VI) is reduced to Cr (III) when it reacts with animal or vegetable material in water. Hutcheson et al., (1975) reported that 20 ppm chromium did not affect the vitality or metabolic functions of rats. Steele et al., (1977) Steele and Rosebrough (1979) reported trivalent chromium as an essential dietary trace-element for swines and turkey respectively. Ryan and Hastings Vogt (1977) reported that a trace amount of chromium in human blood is essential for normal glucose metabolism.

Mikhail and Awadallah (1977) demonstrated that ATP, zinc, manganese and cobalt ions seemed to be essential for insulin secretion and glucose utilization by tissues. Rosson et al., (1979) proposed that chromic ion, nicotinic acid and amino acids form a complex, referred to as glucose tolerance factor, which somehow potentiated insulin action. Such factor, extracted from brewer's yeast, contained glycine, glutamic acid and cysteine as the amino acid component (Toepfer et al., 1977). The total chromium content varied from 0.40 to 0.81 ug/ml dry

weight whereas volatile chromium, the biologically important fraction, ranged from 0.o2 to 0.39 ug/mg dry weight (Tuman et al., 1978).

Apart from the wide application of radioactive chromium in medical diagnosis (Dunn and Goldwein, 1975; Schiffer et al., 1975; Lapchenkov et al., 1973; Suemasu et al., 1970; Turner et al., 1976; Inada and Vetake, 1978; Ichno, 1979), chromium as an element, interferes with the metabolic activities of living organisms. Its poisoning effect depends upon its valency (Fuoco and Papoff, 1975). Juvenile fishes were poisoned by 53 and 24 mg/litre tri - and hexavalent chromium respectively (Negilski, 1976).

According to Kryshtab (1971), exposure of animals to chromium pyrite dust induced fibrosis accompanied by disorders in protein metabolism. 6×10^{-5}M chromium (III) did not increase the swelling of rat liver mitochondria but formed a complex with the intrachain disulphide of insulin (Campbell and Mertz, 1963). In his opinion (Anghileri, 1969), the mechanism of chromium accumulation of tumor cells is not a simple phosphomonesterase action but the interaction of chromium with calcium and/or nucleic acid metabolism was the main cause of such accumulation (Anghileri, 1971). Absorption and accumulation of chromium in blood platelets or erythrocytes sharply decreased with age (Burger et al., 1975; Tsukada et al., 1971; Glomski et al., 1971; Talskaya and Shitikova, 1964).

5 ppm chromium, in drinking water, lowered serum cholesterol and glucose levels in rats (Schroeder et al., 1971). Shakhnazarov (1973) showed that prolonged oral intake of small doses of dichromate, by dogs, (1 mg/kg) decreased the total

glycogen and inhibited the activity of the oxidation reduction and hydrolytic enzymes, with a drop in the -SH groups and ascorbic acid. At higher doses, acid phosphatase activity and RNA synthesis as well as mono amino oxidase were highly increased. According to Hirsch and Pakuts (1975), chromium chloride did not elicit nephrotoxicity or stimulation of N-methyl nicotinamide uptake. The enhancement of renal N-methyl nicotinamide accumulation or retention by potassium dichromate appears to be associated with the nephrotoxicity produced by this compound. Levis et al., (1978) emphasized that stimulation of nucleoside uptake by hamster fibroblasts and human epithelial cells was a specific effect of Cr^{6+} whereas Cr^{3+} always exerted an inhibitory effect. Rae (1978) demonstrated the high hemolytic activity of cobalt, nickel and cobalt-chromium alloy on cells of human tissue culture. They were also the most toxic among several other heavy metals.

Very little had been published on the role of chromium in the physiology and metabolism of plants. In some instances it is considered an indispensable micro-element (Bertrand and De Wolf, 1965, 1968). As early as 1957, 1958, Dobrolyubskii and Slavvo reported that application of 0.6 kg/hectare of chromium sulphate to vines, prior to mass blooming, improved the quality of grapes. The weight and size increased by 21% and 18% respectively. The sugar content and the gluco-acidiometric coefficient were also high. Lower doses (0.15 kg/hectare) were more effective. Similar observations were reported by Bertrand and De Walf 1968) experimenting on potato. In acid soils, chromium sulphate was very toxic to wheat and tomato (Moulinier and Mazeeeyer, 1968). Rusko (1968 a,b) noticed that application of molybdenum, chromium or zinc to

grapes, before flowering, raised the total nitrogen of the grapes and chlorophyll content of leaves. Lobnik and Vidrih (1976) and Vidrih and Lobnik (1976) showed that 7 g/pot of tanning industry sludge (2.4 ppm chromium) gave the highest yield of Dactylis glomerata whereas 1.129 sludge/pot was inhibitory even when coupled with superphosphate to reduce the high amounts of available chromium.

Usually the chromium content of plants is very low but some species can accumulate appreciable amounts of the metal (Lyon et al., 1968). Lee et al., (1977) reported that epiphytic mass "Aerobryopis longissima", the first chromium accumulator among bryophytes, could accumulate up to 7500 ug/g chromium. Banasova (1978), proved that Melilotus officinalis and Calamograstis epigeios were concentrators of chromium from Dobsina locality, Czechoslovakia. Filip et al., (1979) found that Oscillatoria sp. was extremely resistant to chromium and could grow in chromium exposed cultures. From the animal kingdom, Capelli et al., (1978) suggested to use mussels (Mytilus galloprovincialis) as a pollution indicator for several metals including chromium.

The effect of chromium on mineral nutrition have already been discussed (Hewitt, 1948, 1953). Translocation of ionic chromium from roots is blocked through chelation by proteins (Dekock, 1956). On the other hand, Lyon et al. (1969) demonstrated the presence of chromate ions in the xylem sap, indicating that the metabolism of this ion took place in the leaves.

Water culture experiments with Glycine max (Turner and Rust, 1971) showed that 0.5 ppm anionic chromium lowered

the uptake of calcium, potassium, iron, phosphorus, and manganese in roots. In soils 0.60 ppm chromium interfered with accumulation of calcium, potassium, magnesium, phosphorus, boron and copper of tops. At 5 ppm or above, symptoms of toxicity appeared as severe wilting of tops of the treated plants. Chromate was reported to be absorbed freely by barley roots (Shewry and Peterson, 1975). But unless the concentration was high (0.1 mM) less than 1% of the absorbed anion was transported to the shoot. Most of the absorbed ion was found in a non-particulate form in the vacuoles. Skeffington et al. (1976) and Fiusselo and Novo (1976), further reported that chromate was more toxic to growth of several monocot. and dicot. crop plants than chromic though apparent uptake of the latter was much faster. The former authors claimed that chromate uptake was active whereas chromic uptake was passive demonstrating that the two forms did not share a common uptake mechanism.

According to Kick and Braun (1977), concentrations of chromium above 0.5mg/gm soil retarded growth of spring rye, green mustard, winter rye, winter wheat, spinach and rye grass. Rehab and Wallace (1978 a,b) showed that cotton cultivars could tolerate 25 ug chromic ion/g soil above which reduction in leaf yeild was observed.

During the last decade, the role of trace heavy metals on growth and metabolism of lower plants, attracted the attention of several investigators. Thus Lamb and Tollefson (1973) reported that cuppric ions were most toxic, followed by chromate and chromic, to activated sludge micro-organisms.

Bieszkiewilz and Hoszowski (1978) proved that concentrations, of the above mentioned ions, above 0.8 mg, 20 mg and 15 mg per litre, respectively, inhibited such process as indicated by inferior purification and reduced intensity of respiration of the micro-organisms. Trivalent chromium is recorded among the most effective inhibitors of nitrification in soils (Liang and Tabatabal, 1978); average inhibition being more than 50%. Similarly chromium reduced arylsulphatase activity in soils (Al-Khafaji and Tabatabal, 1979) to varying extents dependent on type of soil.

Among lichens, Parmelia caperata and Parmelia rudecta were able to accumulate chromium particularly in the centre of the thallus (Schutte, 1977). Euglena gracilis could tolerate 1 mg/litre chromium (as chromium trioxide) for only three hours, at room temperature (Yongue et al., 1979). In the meantime, (Mangi et al., 1978) considered chromium (VI) and CrO_4^{-2} as moderately toxic to several riverine algae and to a lesser extent to duck weeds. On the other hand, Petriya (1978) claimed that chromium salts, in waste waters from leather factories, at 10^{-4} and 10^{-5}M stimulated growth and photosynthesis of Chlorella vulgaris whereas higher levels were inhibitory.

Bacteria seem to be more sensitive to chromium than other microorganisms. Hedenstedt et al. (1977) and Nestmann et al. (1979) showed that chromate ion was the responsible agent causing mutagenicity in Escherichia coli and Salmonella typhimurium. According to Petrilli and de Flora (1977), all hexavalent chromium compounds caused complete inhibition of bacterial growth at doses of 400-800 ug per plate but the

trivalent chromium compounds were neither toxic nor mutagenic for Salmonella typhimurium. On the other hand, Pseudomonas aeruginosa (Simon-Pujol et al., 1978; Summers and Jacoby,1978) was resistant to hexavalent chromium whereas Klebsiella aeragenes was more tolerant to the trivalent than hexavalent ion (Baldry et al., 1977). Schatt et al. (1973) showed that chromium was less effective in inhibiting growth of Streptococcus faecalis compared with thorium, iron or copper.

Fungi seem to be more tolerant to heavy metals than other micro-organisms. Schmidt and Ziemer (1976) were of the opinion that the substrate, mass of inoculum and hyphal lesions are the primary influencing factors whereas adaptive or genetic phenomena do not participate in inducing high tolerance of fungi. Wood destroying fungi considerably varied in their tolerance to copper-chromium arsenate. Toxic doses of the substance drastically reduced the colonization of these fungi (Chou et al., 1974) except Poria moticola that remained viable. Marsh et al. (1975) proposed that less than 25 ug per one ml medium of iron, manganese, copper, cadmium, trivalent chromium, silver or mercury partly or completely inhibited aflatoxin production without influencing dry weight of Asperiglus parasiticus. On the other hand, Burzynska and Maciejska (1978) reported increased aflatoxin production by Aspergillus flavus or Aspergillus parasiticus with administration of cadmium or chromium without affecting biomass yield.

B - MATERIAL AND METHODS

40 wooden boxes (60 x 60 x 60 cm diameter) were arranged in open air (protected from birds by a net work). Each box received 300 kg of sieved loamy-clay soil. These were watered, several times, until the soil settled. Duplicate boxes were used for each treatment. Each received 300 seeds from crop yield following 3 times leaf spray with either 5, 10 or 50 x 10^{-5}M of either chromate, dichromate or chromic salt (c.f. Kord, 1978) the remaining 22 boxes received the same amount of untreated seeds of Datura stramonium, kindly supplied by the authorities of the Experimental Station, annexed to the Faculty of Pharmacy, Cairo University.

All boxes received the proper manuring and irrigation regimes following the instructions of the Experimental Station.

The first sample from all boxes was taken after 35 days of germination. Duplicate boxes sown by normal seeds, then received two litres water containing appropriate amounts of chromate, dichromate or chromic to form 5, 10 or 50 x 10^{-5}M concentrations in the soil whereas the remaining treated or untreated seeds received two litres of irrigation water. This procedure was repeated at 45 and 55 days of age. Samples from the forty boxes were then taken after 40, 45, 55, 60 and 65 days of germination.

Leaf number, leaf area, fresh and dry weight as well as chemical analysis and alkaloid content were performed on these samples.

At least 10 replicate plants were taken from each box after thining the germinated seeds to 100.

Chemical Analysis

Chemical analysis was performed on the leaves after grouping them in the three categories. At least 5 replicates, of known weight from each category, were kept in phenol-trichloro acetic acid for 24 hours (Naguib, 1963) before centrifugation fore estimation of carbohydrate components whereas another 5 replicate samples were kept in borate buffer at pH 8, for 24 hours, in order to allow complete extraction of soluble nitrogen and phosphorous components (Naguib, 1969). The extract was centrifuged while the residue was kept, overnight, in 1 N sodium hydroxide, to dissolve the insoluble nitrogen and phosphorous components, then centrifuged.

Estimation of nitrogen, phosphorus components and carbohydrate components was performed using the available colorimetric procedures, at hand. Soluble carbohydrates were estimated in phenol water extract after clearing. This was performed on the neutralized phenol water extract, to phenol red, whereby 3 ml basic lead acetate (13.7%) were added and the mixture was filtered on 3 ml sodium dihydrogen phosphate (11.9%) (c.f. Said and Naguib, 1964). Another filtration was necessary, to remove the excess precipitated lead, before making up the solution to a known volume.

A- Estimation of Soluble Matter :

1- Ammonia Nitrogen:

The procedures mentioned by Fawcett and Scott (1960) and Chaney and Marbach (1962) were followed in this investigation. 1 ml of 5% phenol containing 25 mg sodium nitro-prusside, was added to a known volume of the neutral extract followed by 1 ml of 2% sodium hypochlorite dissolved in 0.63 N sodium hydroxide. The mixture was incubated, at 37^{o}C, for 15 minutes, diluted to the appropriate volume and the optical density determined at 630 nm.

2- Free Amino Nitrogen:

A protein-free sample was made slightly alkaline to phenolphthalein before addition of 1 ml of 1% borax (Russel, 1944). After shaking, another 1 ml of 0.25% freshly prepared naphthoquinone-4-sulphonic acid was added. The mixture was kept in boiling water bath, for 15 minutes, then rapidly cooled. Acid formaline and thiosulphate solutions were added and shaken. The mixture stood 20 minutes before estimation of its colour intensity at 470 nm.

3- Peptide Nitrogen:

The procedures of Lowry et al., (1951) were followed. A sample of the borate extract was mixed with 1 ml freshly mixed (1:1 ratio) solution of 2% sodium-carbonate in 4% sodium hydroxide and 0.5% copper-sulphate in 1% sodium tartarate. The mixture stood 10 minutes before addition of 0.1 ml Folin phenol and made up to volume. The optical density of the mixture was measured, after 30 minutes, at 700 nm.

4- Other Soluble Nitrogen:

If we substract the product of peptide, amino and ammonia nitrogen from the value, obtained experimentally, for total soluble nitrogen, we can calculate the value of other soluble nitrogen, including amide and acyclic nitrogen (purines and pyrimidines).

5- Total Soluble Nitrogen:

A known aliquot of the borate buffer extract was wet digested using 50% sulphuric acid followed by little dilute perchloric acid for complete oxidation, till the whole mixture turned pale green or colourless. This was made up to volume before a known amount was neutralized and its ammonia content estimated by the Berthelot reaction. The values obtained by this procedure, denoted all soluble nitrogen components but nitrate and/or nitrite nitrogen; the latters were of insignificant amounts or even absent from the extracts.

6- Inorganic Phosphorus:

The sulphite metol method, adopted by Burton and Riley (1954), was applied in this investigation. All phosphorus estimations were carried out on neutral samples using phenolphthalein as indicator.

A known volume of the neutralized leaf extract was shaken with 1 ml of 2.5% freshly prepared ammonium molybdate and 0.5 ml of 10 N sulphuric-acid solutions. The mixture was kept standing for 15 minutes before addition of 2 ml metal reagent. The mixture was diluted to the appropriate volume and its optical density was measured at 700 nm, after 30 minutes of standing.

7- Total Soluble Organic Phosphorus:

A known volume of the digest for total soluble nitrogen (item 5, p.13) was withdrawn for the assay of its phosphorus content. If we subtract the value of inorganic phosphorous from that recorded by this procedure, we obtain the value of total soluble organic phosphorus.

8- Total Monosaccharides (Direct Reducing Value)

This is estimated in the cleared phenol water extract. 2 ml solution were mixed with 3 ml modified Nelson's solution and the mixture was kept in boiling water for 15 minutes (Naguib, 1964). After cooling, 3 ml arsenomolybdate solution (Nelson, 1944) were added and the mixture was shaken till effervescence stopped. The coloured solution was made up to volume before photometrically measured at 700 nm.

9- Free Pentoses:

A known aliqout of the cleared phenol water extract was equally mixed with concentrated hydrochloric-ferric chloride mixture. About 0.03 g solid orcinol was added the whole mixture was kept in a water bath for 20 minutes .After cooling the coloured solution was diluted to a defined volume before its intensity was measured at 660 nm (Meijbaum, 1939; Schneider, 1945).

10- Sucrose:

1.5 ml cleared extract were mixed with 0.5 ml. of 0.1% invertase solution. The mixture was incubated for one hour, at 37^{o}C, before its reducing value was determined according to the procedures for the direct reducing value. The difference between the value, obtained by this procedure, and that obtained for the total monosaccharides is the estimate of sucrose, in terms of glucose.

11- Free Hexoses:

If we subtract the value of free pentoses (item 9, p.14) from that of total monosaccharides (item 8,p.14) we obtain the value for free hexoses.

B- Estimation of Insoluble Matter:

1- Total Insoluble Nitrogen:

A known volume of the sodium hydroxide-residue extract was wet digested and its nitrogen content determined following the previously mentioned procedures (item 5, p.13).

2- Protein Nitrogen :

An aliquat of the sodium hydroxide-residue extract was analysed for its protein content using the Folin phenol procedures (item 3, p.12).

3- Other Insoluble Nitrogen :

If we subtract the value obtained by the previous procedure from that of total insoluble nitrogen, we can easily estimate the value of other insoluble nitrogen representing the nucleoprotein nitrogen.

4- Total Insoluble Phosphorus :

A known volume of the digested sodium-hydroxide residue extract (item 1,p.15) was neutralized before its phosphorus content was determined.

5- RNA-Phosphorus :

According to Schmidt and Thanhauser (1945), 5 ml of the sodium hydroxide-residue extract were acidified with 1 ml of 6 N hydrochloric acid and 5 ml of 5% trichloroacetic acid then centrifuged. Both inorganic and total phosphorus were determined in the centrifugate accroding to the previously mentioned procedures. The difference between the two procedures is an estimate of the RNA-phosphorus.

6- DNA-Phosphorus :

If we subtract the total phosphorus reported by the previous procedure (item 5,p.16) from the value of the total insoluble phosphorus (item 4,p.15) we calculate the value of the DNA-phosphorus in the sample.

7- Other Insoluble phosphorus :

This is represented by the figures recorded for the inorganic phosphorus during estimation of RNA-phosphorus (item 5, p.16). In some instances, the phosphorus content of the samples was too low to develop its colour reaction in the previously stated periods of time. Under such conditions, the molybdate mixture was left 30 minutes before addition of the metol reagent after which the whole reaction was kept, for at least 3-4 hours, before being assayed.

8- Total Insoluble Polysaccharides :

A known weight of the residue was refluxed in 1.5 N sulphuric acid, at 100°C for 2 hours (Naguib, 1963). The solution was then neutralized to phenol red, cleared, and made upto volume before its reducing value was estimated (item 8, p.14).

9- Total Pentosans :

The pentosan content of hydrolysate was estimated by the orcinol method. If the value of neucleoprotein pentoses (item 11, p.17) is subtracted from the obtained value, true pentosans could be evaluated.

10- Total Hexosans:

If we substract the value of total pentosans (item 9,p.16)

from that of total insoluble polysaccharides (item 8, p.16) the product will represent the total hexosans.

11- Neucleoprotein Pentoses:

A known weight of the phenol-trichloroacetic residue was refluxed in 5 ml of 5% trichloroacetic acid in a boiling water bath for one hour (Schneider, 1945). The mixture was filtered and its pentose content was estimated by the Meijboum method.

12- Starches:

The use of taka-diastase for the hydrolysis of a known weight of the dry phenol-trichloroacetic residue was quite sufficient to cause (complete hydrolysis of the insoluble starches and/or dextrins. This procedure was followed in the present invesiigation where a known weight of the dried residue was mixed together with 0.2 ml taka-diastase enzyme solution and 0.1 ml acetate buffer (pH 4.5)and incubated overnight at 28-30^{o}C. The mixture was then diluted to 3 ml. with distilled water and centrifuged before its D.R.V. was estimated.

13- Other Hexosans :

If we subtract the value of starches (item 12, p.17) from the value of total hexosans (item 10, p.16) we obtain the value of the other glucosides and hexosans.

14- Uronic acids: (Florenceb et al., 1940).

0.3 ml. of the supernatant of the sodium hydroxide extract of the residue were mixed with 0.2 ml. 0.5% carbazol in absolute ethanol. 1 ml. concentrated sulphuric acid was added and the tubes were kept in a boiling water bath for 10 minutes

then cooled. The mixture was made up to 5 ml with distilled water and its colour intensity was photometrically measured at 535 nm.

Alkaloid Estimation:

The procedures by Hilal et al. (1977) were followed in this investigation :

About 2 g powdered Datura leaves were extracted with 95% ethanol. The cnncentrated alcoholic extract was dissolved in 1% HCl and rendered alkaline with ammonium hydroxide. The alkaloids were exhaustively extracted with successive portions; each of 20 ml. of chloroform. The combined chloroform extract was washed with 10 ml. water, dehydrated over anhydrous sodium sulphate then chloroform was distilled off on a warm water bath. The residue was dissolved in 5 ml methanol and the volume was completed to 10 ml. in a measuring flask. This solution was used for GLC analysis.

Pye Unicam Gas Chromatograph series 104. Model 64 with dual column and frame ionization detector was used. The following conditions were adopted :

The coiled glass column was 5 feet long and- 4 mm internal diameter. It was packed with 3% SE.30 adsorbed on 100-120 mesh diatomite CG. Nitrogen was used as a carrier gas at a flow rate of 50 ml/min. The analysis was carried out isothermally at 225^{o}C at attenuation of 20x 10^{-2} and chart speed of 1 cm/min.

Qualitative identification was carried out comparing the retention time of each peak with those of the available authentic samples. The relative percentage of each alkaloid in each

sample was calculated based on peak area measurement.

Determination of Pigment Content :

0.2 g fresh weight of leaf tissue was soaked in anhydrous 100% acetone and kept at -5°C for at least 12 hours. In an ice cold mortar, the tissues were ground with little purified sand using the least amount of cold acetone and a pinch of magnesium carbonate, to neutralize the plant acids, as well as granular anhydrous sodium sulphate to dehydrate the plant tissue (Sestak et al., 1971). The extract was quantitatively decanted into a centrifuge tube using few mls. of cold acetone. After centrifugation, the cleared extract was quantitatively transferred to a volumetric flask and brought up to volume with acetone.

The absorbance measurements were carried out on Perkin-Elmer spectrophotometer (Model 200-20 Double Beam). The extinction (E) was recorded at 440.5, 644 and 662 nm. the concentration of chlorophyll a and b as well as carotenoids were calculated using the following equations given by Sestak et al., (1971) for 100% acetone.

$$\text{Chlorophyll a (ug/ml)} = 9.78\ E_{662} - 0.99\ E_{644}$$

$$\text{Chlorophyll b (ug/ml)} = 21.4\ E_{644} - 4.65\ E_{662}$$

$$\text{Chlorophyll a+b (ug/ml)} = 5.13\ E_{662} + 20.41\ E_{644}$$

$$\text{Carotenoids (ug/ml)} = 4.69\ E_{440.5} - \text{Chl. (a+b)}\ 0.268.$$

The results obtained from above equations, express the pigments as milligram per liter extract i.e. (ug/ml). The pigment content was then calculated in terms of mg per one g dry weight.

All measurements were carried out within a maximum of 6 hours from the beginning of extraction to avoid adsorption of the pigments on sodium sulphate (Fadeel, 1962).

PART II

A- COMPARATIVE EFFECTS OF PREVIOUS LEAF SPRAY WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM SALTS WITH THE EFFECTS OF SOIL TREATMENT WITH THE SAME CHROMIUM IONS ON FRESH AND DRY WEIGHT, TOTAL LEAF AREA AND PIGMENTATION OF *DATURA STRAMONIUM* LEAVES DURING THE GROWTH SEASON.

P A R T II

A - COMPARATIVE EFFECTS OF PREVIOUS LEAF SPRAY WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM SALTS WITH THE EFFECTS OF SOIL TREATMENT WITH THE SAME CHROMIUM IONS ON FRESH AND DRY WEIGHT, TOTAL LEAF AREA AND PIGMENTATION OF DATURA STRAMONIUM LEAVES DURING THE GROWTH SEASON

In this experiment, the seeds, obtained from previously, 3 times, sprayed Datura stramonium plants (c.f. Kord, 1978) as well untreated seeds were sown in large wooden boxes containing plain loamy clay soil. After 5 weeks of germination, the control plants were irrigated, every 10 days, with 0, 5, 10 or 50×10^{-5} M of either chromate, dichromate or chromic ions, whereas the progeny of the previous treatment was irrigated with water. 10 replicate plant samples were collected after 35, 45, 55 and 65 days, just prior to irrigation.

R E S U L T S

Fresh and Dry Weight :

Table 1 and Fig. 1 show that the fresh weight of leaves of 5 weeks old plants was hardly affected by the earlier spray with the chromium salts except those produced after 50×10^{-5} M dichromate treatment where an appreciable drop was observed; a phenomenon that was partially alleviated with progress of age. On the other hand, an increase in fresh weight of leaves was observed in plants produced from previous spraying with 10×10^{-5}M chromate, during the second sample that was furthered with progress of age resulting in the largest estimates, by the end of the experimental period. Chromic ions exerted their stimulatory effects, nearly during the last sample with minor difference between the different concentrations of the ion.

Table 1: Comparison of effects of previous leaf spray with various concentrations of different chromium salts with the effect of soil treatment with the same chromium ions levels, on fresh and dry weight of main stem leaves of Datura stramonium, and the total area per plant, during the growth season.

Age in days	Concentration x 10^{-5} M	Chromium ion	Weight of leaves (g) Fresh	Weight of leaves (g) Dry	Total leaf area (cm^2)	Age in days	Concentration x 10^{-5} M	Chromium ion	Weight of leaves (g) Fresh	Weight of leaves (g) Dry	Total leaf area (cm^2)
35 Initials before irrigation with water.	0	0	2.64±0.11	0.32±0.014	72.3±2.4	35 Initials before irrigation with chromium.	0	0	2.64±0.11	0.32±0.014	72.3±2.4
	5	Chromate	2.74±0.10	0.36±0.016	61.6±2.0		5	Chromate			
		Dichromate	2.42±0.09	0.38±0.019	57.0±1.9			Dichromate			
		Chromic	2.96±0.13	0.54±0.020	62.5±2.1			Chromic			
	10	Chromate	3.16±0.12	0.48±0.017	55.6±1.8		10	Chromate			
		Dichromate	1.88±0.08	0.22±0.011	53.1±1.8			Dichromate			
		Chromic	2.42±0.08	0.36±0.015	70.1±2.3			Chromic			
	50	Chromate	2.44±0.09	0.36±0.015	59.2±2.0		50	Chromate			
		Dichromate	2.02±0.08	0.28±0.013	50.5±1.7			Dichromate			
		Chromic	2.34±0.09	0.28±0.012	66.4±2.2			Chromic			
45 10 days after 1st irrigation with water.	0	0	2.92±0.11	0.48±0.018	125.0±4.1	45 10 days after 1st irrigation with chromium.	0	0	2.92±0.11	0.48±0.018	125.0±4.1
	5	Chromate	3.04±0.13	0.56±0.021	85.3±2.8		5	Chromate	6.80±0.22	1.24±0.090	152.1±5.1
		Dichromate	2.60±0.10	0.48±0.019	79.0±2.6			Dichromate	3.64±0.15	0.78±0.070	115.1±3.8
		Chromic	3.34±0.14	0.88±0.039	91.4±3.0			Chromic	5.44±0.18	0.82±0.070	207.0±6.8
	10	Chromate	4.24±0.14	0.62±0.023	102.7±3.4		10	Chromate	3.38±0.13	0.96±0.080	126.3±4.2
		Dichromate	3.24±0.13	0.42±0.017	63.7±2.1			Dichromate	3.08±0.12	0.58±0.060	151.4±5.0
		Chromic	2.96±0.12	0.70±0.025	111.5±3.7			Chromic	4.76±0.16	1.16±0.090	226.3±7.5
	50	Chromate	2.94±0.11	0.58±0.022	84.6±2.8		50	Chromate	2.28±0.10	0.80±0.070	107.6±3.6
		Dichromate	2.44±0.10	0.42±0.017	92.7±3.0			Dichromate	2.86±0.12	0.58±0.022	88.0±3.0
		Chromic	2.98±0.12	0.96±0.034	98.7±3.3			Chromic	4.90±0.17	0.86±0.031	190.9±6.3
55 10 days after 2nd irrigation with water.	0	0	3.28±0.13	0.60±0.022	136.8±4.5	55 10 days after 2nd irrigation with chromium.	0	0	3.28±0.13	0.60±0.022	136.8±4.5
	5	Chromate	3.42±0.12	0.82±0.029	108.7±3.6		5	Chromate	9.16±0.29	1.94±0.063	174.3±5.8
		Dichromate	2.90±0.12	0.72±0.026	121.7±4.0			Dichromate	5.68±0.19	1.38±0.046	132.1±4.4
		Chromic	3.86±0.14	1.38±0.046	118.0±3.9			Chromic	7.30±0.25	1.06±0.036	243.3±8.0
	10	Chromate	5.36±0.19	0.80±0.028	147.6±2.7		10	Chromate	4.76±0.19	1.24±0.042	188.0±6.2
		Dichromate	3.48±0.13	0.72±0.025	85.4±2.8			Dichromate	3.92±0.14	0.96±0.034	177.8±5.9
		Chromic	3.44±0.12	1.22±0.041	144.5±4.9			Chromic	7.52±0.25	1.52±0.050	263.0±8.7
	50	Chromate	3.28±0.12	0.92±0.032	121.5±4.1		50	Chromate	3.94±0.15	1.32±0.044	133.3±4.4
		Dichromate	2.78±0.11	0.60±0.021	111.3±3.7			Dichromate	3.22±0.13	0.68±0.025	107.4±3.5
		Chromic	3.64±0.13	1.42±0.047	126.3±4.2			Chromic	6.18±0.21	1.30±0.043	221.2±7.3
65 10 days after 3rd irrigation with water.	0	0	3.62±0.12	0.96±0.033	151.3±5.0	65 10 days after 3rd irrigation with chromium.	0	0	3.62±0.12	0.96±0.033	151.3±5.1
	5	Chromate	3.64±0.12	1.26±0.042	128.7±4.3		5	Chromate	10.72±0.35	2.22±0.072	289.7±9.6
		Dichromate	3.60±0.13	1.16±0.040	140.0±4.6			Dichromate	7.12±0.23	1.76±0.057	155.7±5.2
		Chromic	4.96±0.18	1.92±0.062	130.0±4.3			Chromic	9.54±0.31	1.36±0.045	298.6±3.2
	10	Chromate	6.20±0.21	1.84±0.059	178.5±5.9		10	Chromate	6.54±0.23	1.96±0.064	203.1±6.7
		Dichromate	3.72±0.14	0.96±0.033	97.1±3.3			Dichromate	4.46±0.16	1.22±0.041	189.3±6.2
		Chromic	4.38±0.15	1.61±0.052	167.0±5.6			Chromic	8.24±0.27	1.96±0.063	305.1±10.1
	50	Chromate	3.90±0.14	1.20±0.040	136.0±4.5		50	Chromate	5.70±0.20	1.66±0.055	161.7±5.4
		Dichromate	3.08±0.11	0.76±0.027	137.7±4.6			Dichromate	3.62±0.13	0.92±0.033	112.8±3.7
		Chromic	4.48±0.17	1.66±0.055	144.2±4.8			Chromic	7.08±0.25	1.72±0.056	246.3±8.1

The previous spraying with 5×10^{-5} M chromic ions appreciably increased dry weight gain after 5 weeks of germination; a phenomenon that was furthered with progress of age. The previous treatment with larger doses exerted the same remarkable stimulation at later stages of growth. Similarly, previous treatment with chromate ions increased the dry weight of leaves though to lesser extent compared with respective doses of chromic ions, particularly towards the end of the experimental period. On the other hand, dichromate seemed without effect, if not slightly inhibitory particularly at its larger doses.

On the other hand, soil irrigation with the least dose of either chromium ions, as well as with the larger doses of chromic ion, largely stimulated the gain in fresh and dry weight of leaves that continued with progress of age. Application of larger doses of chromate exerted their stimulatory effect at later stages of growth; a phenomenon that faded with increased concentration of the ion. However, 10×10^{-5} M dichromate was stimulatory only at the latest growth stage whereas the larger dose seemed without effect.

Total Leaf Area :

Table 1 and Fig. 1 also show that previous spraying with 5×10^{-5} M of either chromiun ions highly reduced the total surface area of the produced leaves; a phenomenon that persisted all over the experimental period; dichromate exerted the comparatively least effect particularly towards the end of the experimental period. Further increase in concentration of either chromate or dichromate was still inhibitory whereas that of chromic exerted no effect; a phenomenon that persisted during the whole season except for 10×10^{-5} M chromate where the inhibitory effects were almost overcome, with progress of age.

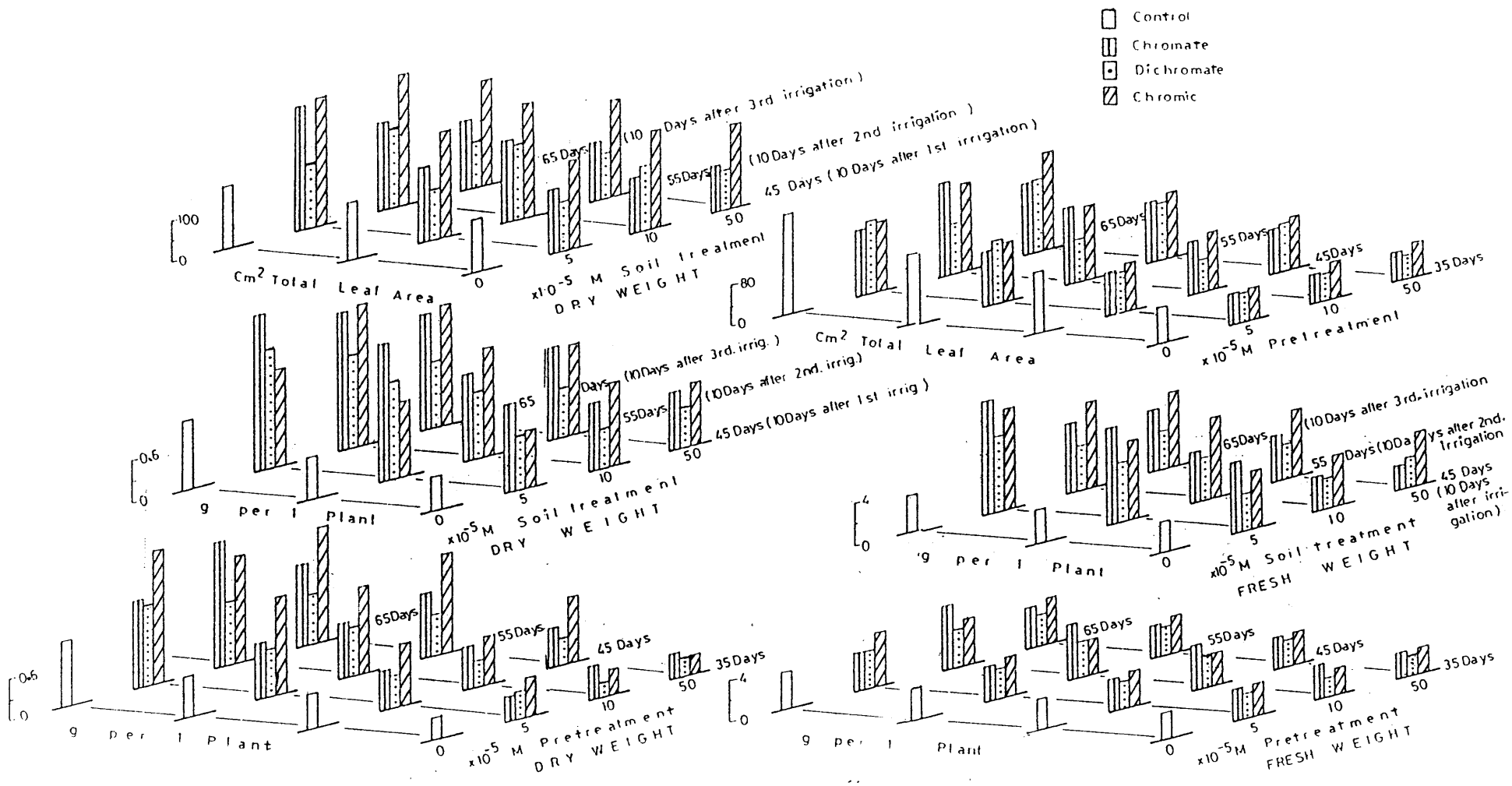


Fig.(1) Comparative effects of previous leaf spray with various concentrations of different chromium ions with the effect of soil treatment with the same chromium ions levels, on fresh and dry weight of main stem leaves of Datura stramonium; and the total leaf area per plant, during the growth season.

Soil treatment with chromate or chromic ions stimulated the increase in surface area of the leaves; the latter ion being more effective than the former, whereas dichromate ions were almost without effect, a phenomenon that continued with repeated application of the same concentration of the ions. Larger doses of chromate or dichromate were inhibitory; the latter ion being more effective than the former; whereas those of chromic were still stimulatory. Repeated application of the ions counteracted the earlier inhibitory effects of chromate without affecting those of dichromate or the stimulatory effects of chromic ions.

Leaf Pigmentation :

Table 2 and Fig. 2 show that previous spraying with the various doses of the different chromium ions exerted no effect on pigmentation except for chromate ions at 10×10^{-5} M and chromic at 5×10^{-5} M that stimulated and 10×10^{-5} M dichromate ions that inhibited chrlorophyll formation, mainly chlorophyll a. With progress of age, the various chromate or dichromate treatments were suppressive to accumulation of both chlorophylls whereas chromic ions were initiative; more prominently at 10×10^{-5} M concentration. On the contrary, only 5×10^{-5} M chromic ions enhanced carotenoid accumulation whereas the other levels of either chromium ions seemed without effect. With progress of age, chromic ions were still stimulatory, particularly at 10×10^{-5} M level, whereas the chromate and dichromate ions were suppressive to carotenoid accumulation.

On the other hand, soil treatment with dichromate or chromic ions increased whereas chromate decreased both chlorophylls content; chromic ions being more effective. Under all conditions, both chlorophyll a and b shared in the drop in total chlorophyll whereas the increase was mainly in chlorophyll a level. Similarly, carotenoid accumulation was highly initiated by chromic or dichromate ions - though to a lesser extent under

Table 2: Comparison of effect of previous leaf spray with various concentrations of different chromium salts with the effect of soil treatment with the same chromium ions on pigmentation of *Datura stramonium* leaves, during the growth season. (mg per 1 g dry weight).

Age in days	Concentration x 10^{-5} M	Chromium ion	Chlorophyll a	Chlorophyll b	a + b	Carotenoids
35 Initials before irrigation with water.	0	0	8.02±0.27	2.73±0.11	10.75±0.36	3.48±0.14
	5	Chromate	6.65±0.22	3.59±0.14	10.24±0.35	3.00±0.12
		Dichromate	7.24±0.24	3.02±0.12	10.26±0.34	2.66±0.11
		Chromic	9.99±0.34	3.59±0.13	13.58±0.44	4.18±0.15
	10	Chromate	12.71±0.42	4.68±0.18	17.39±0.58	2.88±0.12
		Dichromate	5.71±0.20	2.58±0.11	8.29±0.29	2.56±0.10
		Chromic	9.42±0.32	3.01±0.12	12.43±0.41	3.75±0.14
	50	Chromate	7.30±0.24	3.64±0.14	10.94±0.37	2.96±0.12
		Dichromate	7.59±0.25	3.08±0.11	10.67±0.35	3.34±0.11
		Chromic	7.33±0.25	2.71±0.10	10.04±0.34	3.21±0.13
45 10 days after 1st irrigation with water.	0	0	8.16±0.28	3.62±0.13	11.78±0.40	3.41±0.13
	5	Chromate	3.08±0.11	1.69±0.09	4.77±0.18	1.73±0.08
		Dichromate	4.86±0.16	2.82±0.11	7.68±0.26	1.56±0.08
		Chromic	6.26±0.22	3.00±0.12	9.26±0.32	1.17±0.07
	10	Chromate	7.34±0.25	6.22±0.22	13.56±0.45	1.41±0.07
		Dichromate	2.92±0.12	2.34±0.11	6.26±0.21	0.85±0.05
		Chromic	10.55±0.36	4.32±0.15	14.87±0.48	3.30±0.13
	50	Chromate	5.22±0.19	2.63±0.12	7.85±0.25	1.34±0.08
		Dichromate	7.61±0.25	3.52±0.14	11.13±0.36	2.51±0.11
		Chromic	12.55±0.41	4.10±0.14	16.65±0.53	1.99±0.08
55 10 days after 2nd irrigation with water.	0	0	5.44±0.19	2.81±0.11	8.25±0.28	1.91±0.07
	5	Chromate	3.75±0.13	1.83±0.07	5.58±0.20	2.14±0.08
		Dichromate	4.98±0.18	2.02±0.09	7.00±0.23	0.94±0.06
		Chromic	7.77±0.26	3.53±0.15	11.30±0.37	2.81±0.11
	10	Chromate	5.83±0.20	2.05±0.09	7.88±0.28	2.01±0.08
		Dichromate	2.61±0.11	1.19±0.07	3.80±0.15	1.81±0.08
		Chromic	9.53±0.34	3.57±0.14	13.10±0.44	3.34±0.13
	50	Chromate	5.65±0.20	2.34±0.09	7.99±0.28	1.77±0.08
		Dichromate	4.01±0.15	2.10±0.09	6.11±0.22	1.81±0.09
		Chromic	7.72±0.25	3.34±0.14	11.06±0.36	2.76±0.11
65 10 days after 3rd irrigation with water.	0	0	5.52±0.20	2.31±0.09	7.83±0.28	2.06±0.09
	5	Chromate	2.66±0.12	1.61±0.08	4.27±0.17	1.61±0.07
		Dichromate	2.19±0.10	1.05±0.07	3.24±0.14	1.32±0.07
		Chromic	3.61±0.15	1.59±0.09	5.20±0.20	0.91±0.06
	10	Chromate	4.55±0.17	2.00±0.08	6.55±0.23	1.63±0.07
		Dichromate	6.37±0.23	2.07±0.08	8.44±0.29	2.58±0.11
		Chromic	8.63±0.29	3.37±0.14	12.00±0.40	3.07±0.11
	50	Chromate	4.10±0.16	1.37±0.07	5.47±0.20	1.57±0.08
		Dichromate	5.33±0.18	1.87±0.08	7.11±0.24	2.00±0.08
		Chromic	6.77±0.25	2.75±0.11	9.52±0.34	2.24±0.10

Age in days	Concentration x 10^{-5} M	Chromium ion	Chlorophyll a	Chlorophyll b	a + b	Carotenoids
35 Initials before irrigation with chromium.	0	0	8.02±0.27	2.73±0.11	10.75±0.36	3.48±0.14
	5	Chromate				
		Dichromate				
		Chromic				
	10	Chromate				
		Dichromate				
		Chromic				
	50	Chromate				
		Dichromate				
		Chromic				
45 10 days after 1st irrigation with chromium.	0	0	8.16±0.28	3.62±0.13	11.78±0.40	3.41±0.13
	5	Chromate	8.04±0.28	3.10±0.13	11.14±0.36	3.41±0.14
		Dichromate	2.79±0.11	1.94±0.09	4.73±0.17	1.92±0.08
		Chromic	6.98±0.24	2.84±0.12	9.82±0.32	2.71±0.12
	10	Chromate	2.81±0.10	1.66±0.11	4.47±0.16	1.12±0.07
		Dichromate	3.01±0.12	1.98±0.09	4.99±0.18	1.24±0.07
		Chromic	8.75±0.30	3.65±0.14	12.40±0.40	3.45±0.13
	50	Chromate	6.32±0.22	3.21±0.13	9.59±0.33	2.65±0.10
		Dichromate	4.14±0.18	1.83±0.07	5.97±0.21	1.75±0.08
		Chromic	9.00±0.31	3.52±0.13	12.52±0.41	3.45±0.14
55 10 days after 2nd irrigation with chromium.	0	0	5.44±0.19	2.81±0.11	8.25±0.28	1.91±0.07
	5	Chromate	7.41±0.25	3.20±0.12	10.61±0.36	2.65±0.11
		Dichromate	3.24±0.12	1.85±0.08	5.09±0.18	1.05±0.06
		Chromic	6.34±0.23	3.12±0.13	9.46±0.32	2.43±0.10
	10	Chromate	6.08±0.22	2.95±0.12	9.03±0.31	2.04±0.09
		Dichromate	8.73±0.30	5.02±0.18	13.75±0.45	3.00±0.12
		Chromic	9.53±0.33	4.48±0.18	14.01±0.48	3.33±0.12
	50	Chromate	4.64±0.18	2.81±0.11	7.45±0.26	1.88±0.08
		Dichromate	6.72±0.24	3.19±0.12	9.91±0.34	2.45±0.10
		Chromic	11.03±0.36	5.60±0.21	16.63±0.55	3.58±0.13
65 10 days after 3rd irrigation with chromium.	0	0	5.52±0.20	2.31±0.09	7.83±0.28	2.06±0.09
	5	Chromate	3.22±0.12	1.62±0.08	4.84±0.18	1.33±0.07
		Dichromate	2.95±0.11	1.23±0.07	4.18±0.16	1.56±0.08
		Chromic	8.83±0.30	5.02±0.18	13.85±0.46	4.65±0.18
	10	Chromate	3.10±0.12	1.36±0.07	4.46±0.18	1.11±0.07
		Dichromate	4.44±0.17	2.70±0.11	7.14±0.25	1.54±0.07
		Chromic	6.93±0.24	3.39±0.12	10.32±0.35	0.70±0.06
	50	Chromate	3.61±0.14	1.56±0.07	5.17±0.18	1.42±0.07
		Dichromate	7.03±0.24	3.28±0.13	10.31±0.35	2.12±0.08
		Chromic	6.23±0.22	3.22±0.14	9.45±0.32	2.77±0.11

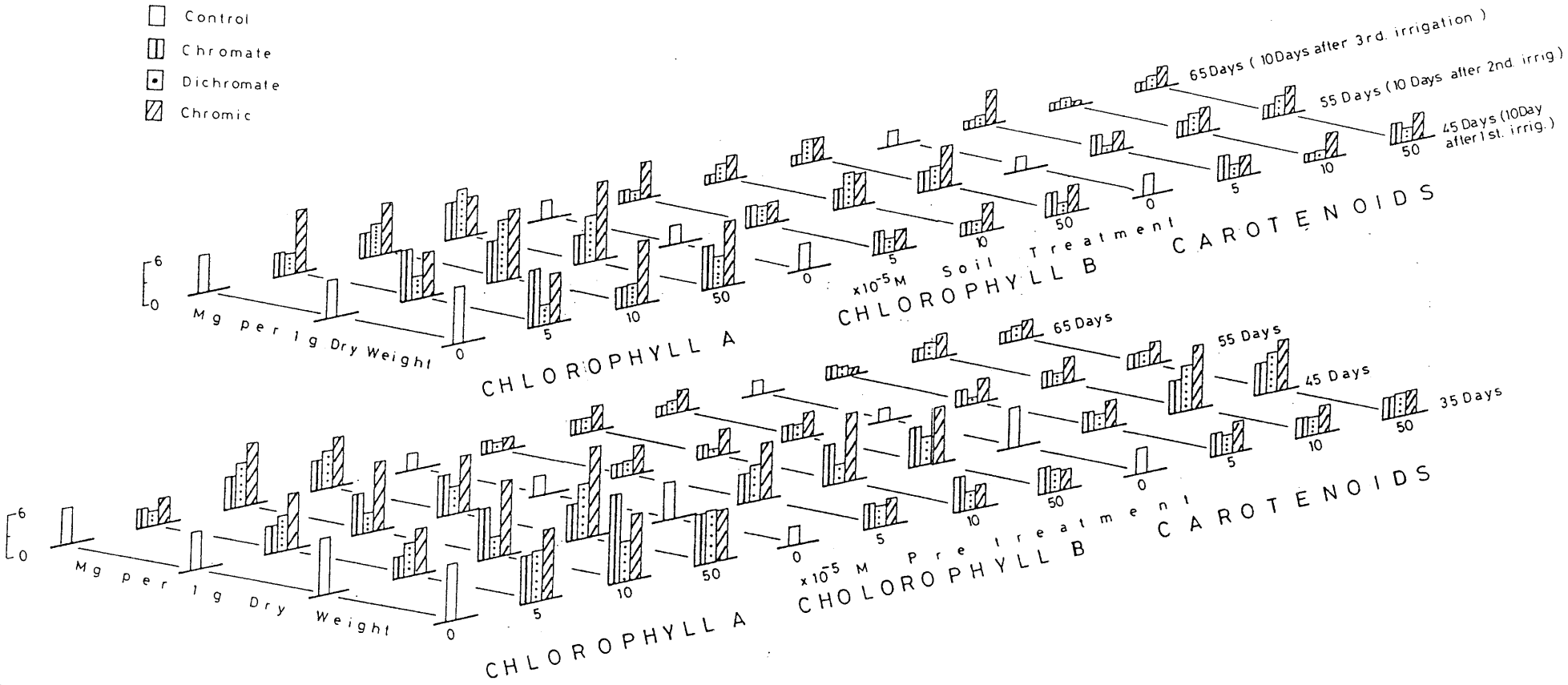


Fig. (2) Comparative effects of previous leaf spray with various concentrations of different chromium ions with the effect of soil treatment with the same chromium ions levels on pigmentation of Datura stramonium leaves, during the growth season. (mg per 1 g dry weight).

the latter condition - whereas chromate ions were mostly inhibitory.

These fluctuations were highly apparent after the second and/or third treatment whereas the first treatment was mostly inhibitory; chlorophyll b being more sensitive than chlorophyll a, in this respect.

B- COMPARATIVE EFFECTS OF PREVIOUS LEAF SPRAY WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM IONS WITH THE EFFECT OF SOIL TREATMENT WITH THE SAME CHROMIUM IONS LEVELS ON THE NITROGEN, CARBOHYDRATE AND PHOSPHORUS CONTENT OF *DATURA STRAMONIUM* LEAVES DURING THE GROWTH SEASON.

B - COMPARATIVE EFFECTS OF PREVIOUS LEAF SPRAY WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM IONS WITH THE EFFECT OF SOIL TREATMENT WITH THE SAME CHROMIUM IONS LEVELS ON THE NITROGEN, CARBOHYDRATE AND PHOSPHORUS CONTENT OF DATURA STRAMONIUM LEAVES DURING THE GROWTH SEASON.

In this part of this investigation the leaves of 10 - 15 plants from each treatment were collectively dried, in hot air dry oven, at $80^{o}C$, ground , thoroughly mixed and 5 replicates; 1 g each, were extracted and analysed for their nitrogen, carbohydrate or phosphorus contents.

R E S U L T S

Nitrogen Content :

Table 3 a and Fig. 3 show that previous spraying with 5×10^{-5} M. of the various chromium ions induced a noticeable drop in total nitrogen content of the leaves, a phenomenon that was not affected by raising the concentration of either chromate or dichromate, (the latter being less effective) but was alleviated or even reversed with increasing the chromic ions dose. Under all conditions, the fluctuations were majorly in the soluble component particularly the other soluble form whereas the insoluble components were slightly, if at all, increased.

With progress of age, the previous treatment with the least dose was mostly inhibitory till the end of the experimental period whereas both the stimulatory or inhibitory effects of previous spraying with the higher concentrations were abolished; more prominently towards the end of the growth season. At the earlier stages of growth (45 - 55 days) chromate at 50×10^{-5} M seemed to stimulate insoluble nitrogen accumulation particularly the other insoluble form on the expense of reduced other soluble

Table 3a: Effect of previous leaf spray with various concentrations of different chromium ions on the nitrogen content of leaves of Datura stramonium during the growth season of the produced seeds. (mg per 1 g dry weight of leaves).

Age in days	Concentration x 10^{-5} M	Chromium ion	Ammonia N	Amino N	Peptide N	Other soluble N	Total soluble N	Protein N	Other insoluble N	Total insoluble N	Total N
35 Initials before irrigation with water.	0	0	1.50 ± 0.08	4.60 ± 0.17	4.57 ± 0.17	58.90 ± 1.95	69.57 ± 2.38	16.47 ± 0.56	7.53 ± 0.27	24.00 ± 0.82	93.57 ± 3.14
	5	Chromate	1.30 ± 0.07	2.26 ± 0.10	4.64 ± 0.16	25.44 ± 0.84	33.64 ± 1.12	18.17 ± 0.63	6.98 ± 0.25	25.15 ± 0.83	58.79 ± 1.96
		Dichromate	1.68 ± 0.08	4.19 ± 0.16	4.86 ± 0.18	39.55 ± 1.44	50.28 ± 1.68	19.41 ± 0.68	6.32 ± 0.24	25.73 ± 0.84	76.01 ± 2.51
		Chromic	2.58 ± 0.11	3.95 ± 0.14	5.94 ± 0.22	22.10 ± 0.73	34.57 ± 1.17	15.75 ± 0.56	5.17 ± 0.19	20.92 ± 0.71	55.49 ± 1.85
	10	Chromate	1.29 ± 0.07	4.07 ± 0.15	6.14 ± 0.21	22.92 ± 0.76	34.47 ± 1.13	16.23 ± 0.57	6.37 ± 0.23	22.50 ± 0.78	56.97 ± 1.90
		Dichromate	1.67 ± 0.08	3.41 ± 0.13	4.57 ± 0.17	36.44 ± 1.20	46.09 ± 1.55	18.44 ± 0.63	12.72 ± 0.42	31.16 ± 1.04	77.25 ± 2.57
		Chromic	1.57 ± 0.08	5.20 ± 0.20	5.58 ± 0.20	54.70 ± 1.82	67.05 ± 2.24	20.41 ± 0.69	10.11 ± 0.34	30.52 ± 1.03	97.57 ± 3.23
	50	Chromate	1.83 ± 0.07	4.12 ± 0.16	5.74 ± 0.21	20.57 ± 0.68	32.26 ± 1.10	16.93 ± 0.59	9.20 ± 0.32	26.13 ± 0.88	58.39 ± 1.95
		Dichromate	1.61 ± 0.07	3.40 ± 0.14	4.48 ± 0.18	41.75 ± 1.38	51.24 ± 1.69	15.53 ± 0.56	7.47 ± 0.23	23.00 ± 0.77	74.24 ± 2.35
		Chromic	2.69 ± 0.11	6.01 ± 0.21	6.61 ± 0.22	62.39 ± 2.06	77.70 ± 2.57	15.86 ± 0.57	9.35 ± 0.31	25.21 ± 0.85	102.91 ± 3.42
45 10 days after 1st irrigation with water.	0	0	0.97 ± 0.05	4.43 ± 0.15	6.10 ± 0.20	41.28 ± 1.36	52.78 ± 1.76	15.76 ± 0.55	9.92 ± 0.34	25.68 ± 0.86	78.46 ± 2.61
	5	Chromate	0.35 ± 0.04	3.34 ± 0.12	6.97 ± 0.25	18.43 ± 0.62	32.29 ± 1.09	19.61 ± 0.66	7.74 ± 0.25	27.37 ± 0.91	59.66 ± 1.98
		Dichromate	1.09 ± 0.07	4.49 ± 0.16	6.85 ± 0.25	24.84 ± 0.83	37.27 ± 1.23	18.40 ± 0.63	9.77 ± 0.34	28.17 ± 0.95	65.44 ± 2.17
		Chromic	1.33 ± 0.07	4.19 ± 0.15	7.61 ± 0.26	17.34 ± 0.57	30.47 ± 1.03	16.70 ± 0.58	9.59 ± 0.35	26.29 ± 0.92	56.76 ± 1.89
	10	Chromate	0.89 ± 0.05	4.41 ± 0.15	8.08 ± 0.28	18.53 ± 0.63	31.85 ± 1.07	17.04 ± 0.59	8.11 ± 0.28	25.15 ± 0.84	57.00 ± 1.89
		Dichromate	0.83 ± 0.05	3.76 ± 0.14	6.03 ± 0.21	25.09 ± 0.84	35.71 ± 1.20	18.97 ± 0.66	10.70 ± 0.37	29.67 ± 1.02	65.38 ± 2.18
		Chromic	0.85 ± 0.05	4.99 ± 0.18	7.29 ± 0.24	25.76 ± 0.83	38.89 ± 1.31	19.47 ± 0.67	16.32 ± 0.56	35.79 ± 1.21	74.68 ± 2.46
	50	Chromate	0.81 ± 0.05	4.46 ± 0.16	7.73 ± 0.25	21.42 ± 0.69	34.42 ± 1.15	15.69 ± 0.56	16.06 ± 0.55	31.75 ± 1.07	66.17 ± 2.20
		Dichromate	1.06 ± 0.06	3.65 ± 0.14	6.79 ± 0.23	25.26 ± 0.84	36.76 ± 1.13	16.62 ± 0.58	11.22 ± 0.39	27.54 ± 0.94	64.60 ± 2.15
		Chromic	1.30 ± 0.07	5.44 ± 0.21	8.45 ± 0.28	36.41 ± 1.21	51.60 ± 1.73	15.67 ± 0.55	11.46 ± 0.41	27.13 ± 0.92	78.73 ± 2.61
55 10 days after 2nd irrigation with water.	0	0	0.62 ± 0.05	4.47 ± 0.17	7.80 ± 0.27	28.62 ± 0.98	41.51 ± 1.42	23.96 ± 0.82	15.21 ± 0.54	38.17 ± 1.32	79.68 ± 2.69
	5	Chromate	0.53 ± 0.05	3.52 ± 0.14	8.57 ± 0.30	16.67 ± 0.56	29.29 ± 1.00	21.09 ± 0.73	7.33 ± 0.27	28.42 ± 0.98	57.71 ± 1.93
		Dichromate	0.71 ± 0.06	3.87 ± 0.15	9.39 ± 0.33	22.81 ± 0.77	36.78 ± 1.25	18.35 ± 0.65	12.28 ± 0.42	30.63 ± 1.05	67.41 ± 2.25
		Chromic	0.90 ± 0.07	4.39 ± 0.16	9.16 ± 0.32	13.28 ± 0.45	27.73 ± 0.95	16.88 ± 0.59	14.52 ± 0.49	31.40 ± 1.06	59.13 ± 1.98
	10	Chromate	0.59 ± 0.06	3.03 ± 0.12	10.57 ± 0.35	16.89 ± 0.57	31.08 ± 1.05	22.74 ± 0.79	11.42 ± 0.39	34.16 ± 1.16	65.24 ± 2.19
		Dichromate	0.63 ± 0.06	3.94 ± 0.15	7.60 ± 0.26	19.30 ± 0.67	31.47 ± 1.08	19.42 ± 0.68	15.88 ± 0.52	35.30 ± 1.19	66.77 ± 2.22
		Chromic	0.62 ± 0.05	4.16 ± 0.15	8.57 ± 0.29	28.72 ± 0.97	42.07 ± 1.42	15.09 ± 0.54	15.70 ± 0.51	30.79 ± 1.04	72.86 ± 2.42
	50	Chromate	0.48 ± 0.05	4.53 ± 0.17	9.61 ± 0.33	19.83 ± 0.67	34.45 ± 1.17	22.13 ± 0.77	32.20 ± 1.06	54.33 ± 1.81	88.78 ± 2.95
		Dichromate	0.87 ± 0.07	4.01 ± 0.15	8.76 ± 0.29	26.49 ± 0.92	40.13 ± 1.24	19.14 ± 0.67	15.48 ± 0.52	34.62 ± 1.17	74.75 ± 2.42
		Chromic	0.94 ± 0.07	4.25 ± 0.16	9.15 ± 0.31	33.70 ± 1.14	48.04 ± 1.58	17.27 ± 0.61	13.69 ± 0.45	30.96 ± 1.04	79.00 ± 1.61
65 10 days after 3rd irrigation with water	0	0	0.32 ± 0.05	3.33 ± 0.14	9.91 ± 0.34	13.77 ± 0.48	27.33 ± 0.93	22.74 ± 0.78	26.25 ± 0.88	48.99 ± 1.63	76.32 ± 2.53
	5	Chromate	0.38 ± 0.05	3.52 ± 0.15	10.97 ± 0.37	15.42 ± 0.54	30.29 ± 1.05	22.81 ± 0.79	8.19 ± 0.30	31.00 ± 1.06	61.29 ± 2.07
		Dichromate	0.46 ± 0.04	3.11 ± 0.13	8.99 ± 0.30	22.61 ± 0.78	35.17 ± 1.21	18.07 ± 0.63	17.02 ± 0.57	35.09 ± 1.18	70.26 ± 2.37
		Chromic	0.64 ± 0.05	3.94 ± 0.14	11.52 ± 0.38	9.41 ± 0.31	25.51 ± 0.89	19.00 ± 0.68	18.99 ± 0.63	37.99 ± 1.27	63.50 ± 2.14
	10	Chromate	0.34 ± 0.04	4.75 ± 0.18	12.67 ± 0.41	17.33 ± 0.60	35.09 ± 1.20	28.59 ± 0.98	14.37 ± 0.48	42.96 ± 1.43	78.05 ± 2.59
		Dichromate	0.46 ± 0.05	3.26 ± 0.14	9.59 ± 0.32	19.93 ± 0.67	33.23 ± 1.13	16.61 ± 0.58	25.43 ± 0.58	42.04 ± 1.41	75.27 ± 2.51
		Chromic	0.38 ± 0.05	3.43 ± 0.15	9.47 ± 0.31	26.47 ± 0.92	39.75 ± 1.35	24.13 ± 0.83	17.94 ± 0.60	42.07 ± 1.40	81.82 ± 2.73
	50	Chromate	0.20 ± 0.04	3.73 ± 0.15	11.49 ± 0.37	16.11 ± 0.56	31.53 ± 1.09	18.39 ± 0.65	17.42 ± 0.58	35.81 ± 1.19	67.34 ± 2.25
		Dichromate	0.61 ± 0.05	3.52 ± 0.14	9.26 ± 0.31	26.65 ± 0.91	40.04 ± 1.36	19.70 ± 0.69	19.56 ± 0.65	39.26 ± 1.32	79.30 ± 2.65
		Chromic	0.69 ± 0.06	4.15 ± 0.16	10.35 ± 0.35	34.16 ± 1.17	49.35 ± 1.67	18.10 ± 0.64	12.23 ± 0.42	30.33 ± 1.03	79.68 ± 2.67

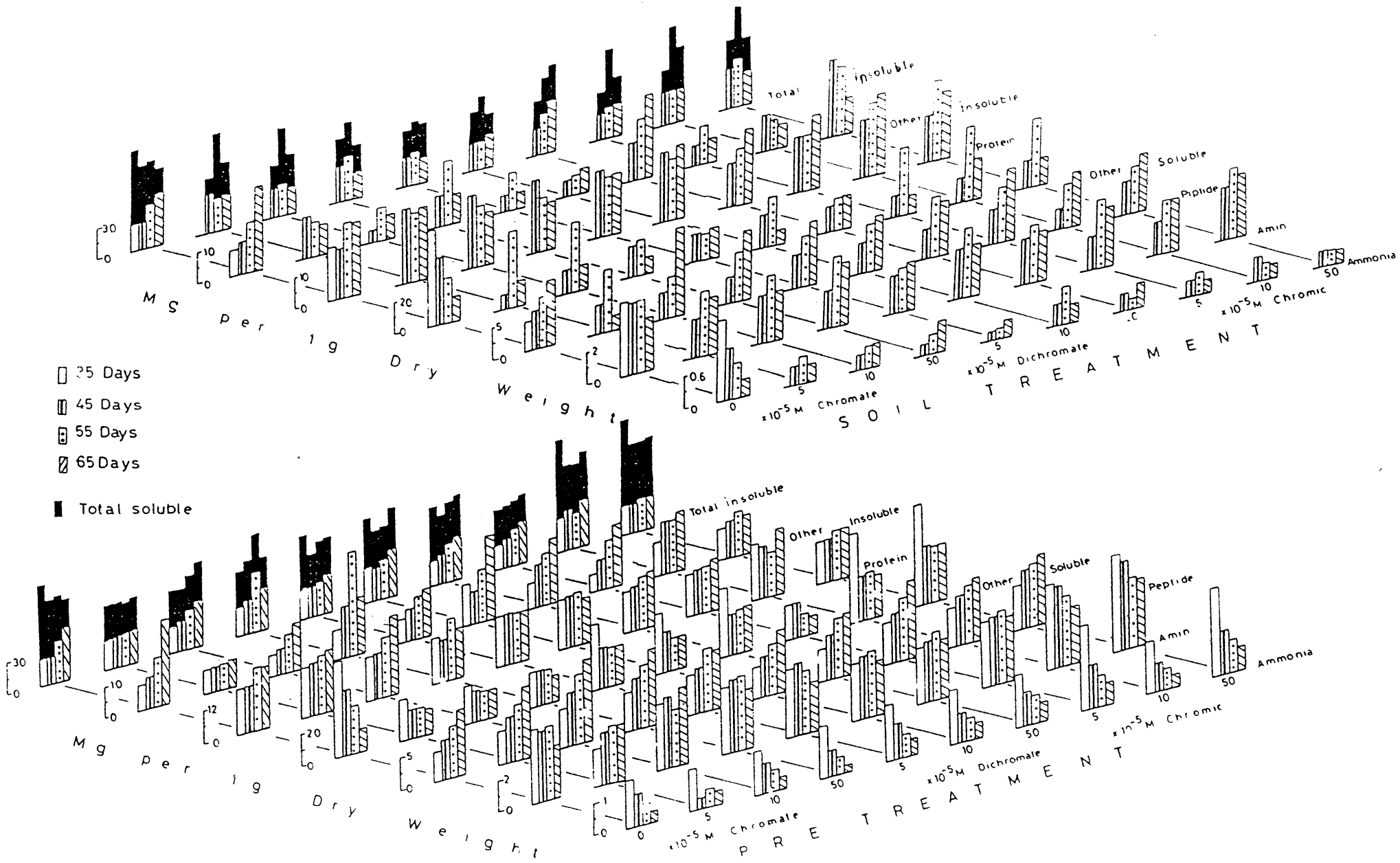


Fig.(3) Comparative effects of previous leaf spray with various concentrations of different chromium ions with the effects of soil treatment with the same chromium ions levels on the nitrogen content of leaves of Datura stramonium during the growth season (mg per 1 g dry weight of leaves)

component, whereas by the end of the experiment, all treatments suppressed insoluble nitrogen formation; the other insoluble participating to a larger extent than the protein nitrogen. This was accompanied by a concomitant increase in the other soluble nitrogen whereas the fluctuations in the other soluble forms were mostly minor.

Table 3 b and Fig. 3 further show that the first soil treatment with either chromate, dichromate or chromic ions inhibited total nitrogen accumulation in Datura stramonium leaves; a phenomenon that was almost unaffected by increasing the dose of the ions except chromic where the higher concentrations partially alleviated such effect. Most of the drop was in the soluble components particularly the other soluble form. In the meantime, though total insoluble nitrogen seemed unaffected by such treatment yet the smaller doses of the chromium ions favoured greater protein than other insoluble nitrogen accumulation whereas the larger doses initiated the reverse effects.

The second application of chromate or chromic ions increased whereas dichromate ions severely attenuated nitrogen accumulations; a phenomenon that was almost completely alleviated at the higher concentrations of either ions except chromic that was still stimulatory. Under these conditions, the increase was mainly in the soluble component, particularly the other soluble nitrogen whereas the drop was mainly in either the other soluble or other insoluble forms; with minor participation from the other nitrogen forms.

The third application of either ions, at their different levels, was totally inhibitary to total nitrogen accumulation, almost to the same extent regardless concentration and/or type of ion. The insoluble component, particularly the other insoluble form, was largely participating in this respect.

Table 3b: Effect of soil treatment with various concentrations of different chromium ions on the nitrogen content of leaves of *Datura stramonium* during the growth season. (mg per 1 g dry weight of leaves).

Age in days	Concentration x 10^{-5} M	Chromium ion	Ammonia N	Amino N	Peptide N	Other soluble N	Total soluble N	Protein N	Other insoluble N	Total insoluble N	Total N
35	0	0	1.50 ± 0.08	4.60 ± 0.17	4.57 ± 0.17	58.90 ± 1.95	69.57 ± 2.38	16.47 ± 0.56	7.53 ± 0.27	24.00 ± 0.82	93.57 ± 3.14
45 10 days after 1st irrigation with chromium.	0	0	0.97 ± 0.05	4.43 ± 0.15	6.10 ± 0.20	41.28 ± 1.36	52.78 ± 1.76	15.76 ± 0.55	9.92 ± 0.34	25.68 ± 0.86	78.46 ± 2.61
	5	Chromate	0.33 ± 0.04	2.42 ± 0.10	4.52 ± 0.18	8.51 ± 0.31	15.78 ± 0.55	22.85 ± 0.79	12.95 ± 0.45	35.80 ± 1.20	51.58 ± 1.65
		Dichromate	0.18 ± 0.03	2.38 ± 0.10	5.16 ± 0.19	17.99 ± 0.63	25.71 ± 0.89	20.89 ± 0.72	5.29 ± 0.20	26.18 ± 0.90	51.89 ± 1.68
		Chromic	0.54 ± 0.04	2.22 ± 0.11	5.48 ± 0.20	14.07 ± 0.49	22.11 ± 0.78	17.33 ± 0.61	6.35 ± 0.23	23.68 ± 0.82	45.79 ± 1.55
	10	Chromate	0.26 ± 0.03	2.97 ± 0.12	3.92 ± 0.16	15.32 ± 0.53	22.47 ± 0.77	22.34 ± 0.78	4.05 ± 0.16	26.39 ± 0.90	48.86 ± 1.66
		Dichromate	0.53 ± 0.04	3.10 ± 0.13	4.71 ± 0.18	21.01 ± 0.72	29.35 ± 1.01	22.08 ± 0.78	4.80 ± 0.19	26.88 ± 0.94	56.23 ± 1.90
		Chromic	0.49 ± 0.04	2.07 ± 0.09	3.25 ± 0.14	16.12 ± 0.55	21.93 ± 0.77	17.80 ± 0.62	11.77 ± 0.39	29.57 ± 1.01	51.50 ± 1.75
	50	Chromate	0.21 ± 0.04	2.43 ± 0.11	4.00 ± 0.16	20.21 ± 0.70	26.85 ± 0.92	22.54 ± 0.79	10.21 ± 0.35	32.75 ± 1.12	59.60 ± 2.00
		Dichromate	0.33 ± 0.05	2.92 ± 0.13	4.49 ± 0.16	17.08 ± 0.60	25.27 ± 0.84	13.42 ± 0.48	12.04 ± 0.44	25.46 ± 0.88	50.73 ± 1.71
		Chromic	0.31 ± 0.05	3.37 ± 0.14	5.26 ± 0.19	17.82 ± 0.61	26.76 ± 0.92	14.45 ± 0.51	24.10 ± 0.82	38.55 ± 1.32	65.31 ± 2.20
55 10 days after 2nd irrigation with chromium.	0	0	0.62 ± 0.05	4.47 ± 0.17	7.80 ± 0.27	28.62 ± 0.98	41.51 ± 1.42	22.96 ± 0.82	15.21 ± 0.54	38.17 ± 1.32	79.68 ± 2.69
	5	Chromate	0.49 ± 0.06	4.01 ± 0.14	9.59 ± 0.33	45.88 ± 1.53	59.97 ± 2.02	21.21 ± 0.75	10.73 ± 0.40	31.94 ± 1.11	91.91 ± 3.09
		Dichromate	0.20 ± 0.04	2.71 ± 0.11	8.03 ± 0.28	18.10 ± 0.62	29.04 ± 1.00	18.20 ± 0.65	11.38 ± 0.41	29.58 ± 1.02	58.62 ± 1.98
		Chromic	0.41 ± 0.05	4.25 ± 0.16	8.44 ± 0.29	41.71 ± 1.41	54.81 ± 1.84	16.90 ± 0.60	11.66 ± 0.42	28.56 ± 1.00	83.37 ± 2.82
	10	Chromate	0.38 ± 0.05	4.11 ± 0.15	6.00 ± 0.22	41.77 ± 1.40	52.26 ± 1.77	18.63 ± 0.66	9.84 ± 0.34	28.47 ± 1.01	80.73 ± 2.70
		Dichromate	0.68 ± 0.07	4.18 ± 0.15	7.30 ± 0.26	31.25 ± 1.06	43.41 ± 1.35	18.67 ± 0.65	5.73 ± 0.23	24.40 ± 0.85	67.81 ± 2.22
		Chromic	0.30 ± 0.04	3.26 ± 0.13	6.87 ± 0.24	46.18 ± 1.55	56.61 ± 1.90	21.78 ± 0.75	9.16 ± 0.32	30.94 ± 1.07	87.55 ± 2.93
	50	Chromate	0.37 ± 0.04	4.41 ± 0.16	7.50 ± 0.27	21.53 ± 0.72	33.81 ± 1.15	16.16 ± 0.58	22.30 ± 0.78	38.46 ± 1.34	72.27 ± 2.44
		Dichromate	0.20 ± 0.04	3.59 ± 0.15	9.14 ± 0.33	21.26 ± 0.71	34.19 ± 1.17	17.46 ± 0.61	18.41 ± 0.64	35.87 ± 1.21	70.06 ± 2.35
		Chromic	0.28 ± 0.04	4.46 ± 0.15	7.37 ± 0.26	41.59 ± 1.41	53.70 ± 1.81	24.56 ± 0.85	21.55 ± 0.75	46.11 ± 1.57	99.81 ± 3.34
65 10 days after 3rd irrigation with chromium.	0	0	0.32 ± 0.04	3.33 ± 0.14	9.91 ± 0.34	13.77 ± 0.48	27.33 ± 0.93	22.74 ± 0.78	26.25 ± 0.88	48.99 ± 1.63	76.32 ± 2.53
	5	Chromate	0.32 ± 0.05	3.61 ± 0.13	2.33 ± 0.11	14.64 ± 0.48	30.90 ± 1.05	22.36 ± 0.78	9.54 ± 0.36	31.90 ± 1.12	62.18 ± 2.14
		Dichromate	0.32 ± 0.04	2.98 ± 0.11	10.10 ± 0.34	19.09 ± 0.66	32.49 ± 1.12	18.52 ± 0.65	4.78 ± 0.18	23.30 ± 0.82	55.79 ± 1.90
		Chromic	0.28 ± 0.04	3.84 ± 0.13	11.26 ± 0.38	12.25 ± 0.42	27.63 ± 0.95	22.62 ± 0.79	7.29 ± 0.28	29.91 ± 1.03	57.54 ± 1.96
	10	Chromate	0.42 ± 0.05	3.09 ± 0.12	13.59 ± 0.45	15.36 ± 0.50	32.46 ± 1.11	16.03 ± 0.57	7.58 ± 0.30	23.61 ± 0.82	56.07 ± 1.90
		Dichromate	0.35 ± 0.04	3.19 ± 0.11	8.64 ± 0.30	9.12 ± 0.32	21.30 ± 0.74	22.97 ± 0.80	7.37 ± 0.27	30.34 ± 1.05	51.64 ± 1.75
		Chromic	0.28 ± 0.04	3.31 ± 0.13	8.44 ± 0.29	25.82 ± 0.81	37.85 ± 1.30	24.38 ± 0.83	7.69 ± 0.30	32.07 ± 1.10	69.92 ± 2.35
	50	Chromate	0.38 ± 0.04	3.94 ± 0.14	10.70 ± 0.36	11.47 ± 0.38	26.49 ± 0.91	14.54 ± 0.52	8.98 ± 0.32	23.52 ± 0.81	50.01 ± 1.70
		Dichromate	0.49 ± 0.05	3.11 ± 0.12	8.49 ± 0.30	20.82 ± 0.67	33.36 ± 1.14	23.20 ± 0.82	25.66 ± 0.90	48.86 ± 1.67	82.22 ± 2.79
		Chromic	0.24 ± 0.04	3.95 ± 0.15	9.01 ± 0.31	17.25 ± 0.55	30.45 ± 1.04	20.71 ± 0.71	11.14 ± 0.40	31.85 ± 1.10	62.30 ± 2.10

Carbohydrate Content :

Table 4 a and Fig. 4 show that previous spraying with chromate seemed to exert no effect on the total carbohydrate content of 5 weeks old Datura stramonium leaves whereas dichromate stimulated and chromic inhibited carbohydrate accumulation; particularly with previous application of the larger doses. The increase was less apparent while the decrease was more prominent with 50×10^{-5} M level. Under all conditions, starch increased; more prominently with previous applications of dichromate whereas other hexosans decreased, except with larger total carbohydrate accumulation where a noticeable increase was observed at 10×10^{-5} M dichromate.

Similarly the total soluble sugars content was low, as a result of inhibited accumulation of sucrose except with previous applications of 50×10^{-5} M dichromate where the remarkable increase in sucrose content favoured a high total soluble sugar content.

With progress of age, previous treatment with chromate or dichromate were always stimulatory whereas chromic ions were inhibitory to total carbohydrate accumulation, particularly at their larger doses. Still, dichromate favoured the largest accumulation of sucrose and hexoses, that was furthered with rise of concentration. Starch also increased, more prominently with previous application of smaller than larger doses of the ion; whereas the other hexasons seemed unaffected.

The stimulatory effect of chromate was less apparent on soluble components, with progress of age and/or concentration of the previous treatment. Nucleoprotein pentoses decreased whereas starch or uronic acids were not affected but other hexasons remarkably increased. In the meantime , the retarding effects of chromic ions were most apparent in the other

Table 4a: Effect of previous leaf spray with various concentrations of different chromium ions on the carbohydrate content of leaves of Datura stramonium, during the growth season of the produced seeds. (mg per 1 g dry weight of leaves).

Age in days	Concentration x 10^{-5} M	Chromium ion	Hexoses	Pentoses	Sucrose	Total soluble sugars	Nucleoprotein pentoses	Other pentosans	Starch	Other hexosans	Uronic acids	Total polysaccharides	Total carbohydrate
35 Initial before irrigation with water.	0	0	5.02±0.19	3.79±0.15	18.90±0.61	27.71±0.92	4.58±0.18	6.59±0.24	12.45±0.42	36.54±1.25	10.51±0.36	70.67±2.36	98.38±3.19
	5	Chromate	7.07±0.25	3.98±0.16	8.05±0.28	19.10±0.65	4.44±0.17	8.55±0.30	21.72±0.74	36.84±1.24	8.47±0.29	80.07±2.68	99.12±3.30
		Dichromate	4.86±0.18	2.82±0.12	13.55±0.45	21.23±0.73	4.01±0.16	8.64±0.31	25.01±0.86	17.07±0.58	9.90±0.34	64.63±2.16	85.86±2.88
		Chromic	2.37±0.11	2.93±0.13	12.35±0.41	17.65±0.62	5.33±0.20	8.44±0.29	22.20±0.75	38.28±1.30	7.61±0.27	81.86±2.72	99.51±3.33
	10	Chromate	10.28±0.35	2.03±0.11	12.31±0.42	24.62±0.85	3.40±0.14	8.58±0.29	21.03±0.71	16.56±0.57	14.08±0.48	63.65±2.13	88.27±2.96
		Dichromate	10.34±0.34	1.06±0.07	14.79±0.51	26.19±0.90	5.69±0.21	8.61±0.30	28.90±0.98	16.78±2.22	8.93±0.31	118.91±3.96	145.10±4.82
		Chromic	2.16±0.10	1.52±0.07	8.94±0.31	14.62±0.47	5.27±0.20	7.69±0.28	20.10±0.68	28.84±0.97	5.06±0.19	66.66±2.24	79.28±2.65
	50	Chromate	7.28±0.26	1.14±0.08	7.77±0.27	16.19±0.55	3.91±0.16	6.93±0.25	28.56±0.97	33.71±1.12	7.44±0.26	80.55±2.69	96.74±3.22
		Dichromate	6.36±0.23	1.71±0.08	42.26±1.42	50.33±1.69	6.25±0.23	7.42±0.27	23.92±0.81	37.97±1.27	9.93±0.33	79.50±2.58	129.83±4.32
		Chromic	3.11±0.13	2.01±0.10	14.64±0.48	19.76±0.68	3.19±0.13	6.23±0.24	20.82±0.71	16.52±0.57	4.08±0.16	50.84±1.69	70.60±2.36
45 10 days after 1st irrigation with water.	0	0	4.19±0.16	3.18±0.13	18.17±0.60	25.54±0.87	5.63±0.20	8.74±0.30	19.27±0.66	48.76±1.65	9.67±0.33	92.07±3.06	117.61±3.95
	5	Chromate	6.83±0.25	3.47±0.14	18.06±0.59	28.36±0.96	4.17±0.17	11.89±0.40	19.12±0.64	47.89±1.62	8.22±0.29	91.29±3.03	119.65±4.00
		Dichromate	4.88±0.19	3.69±0.15	21.57±0.72	30.14±1.04	3.54±0.14	12.96±0.43	26.31±0.88	21.37±0.73	7.81±0.28	71.99±2.40	102.13±3.39
		Chromic	3.02±0.13	2.95±0.12	14.69±0.49	20.66±0.71	4.92±0.19	11.07±0.37	15.43±0.53	59.36±1.98	8.72±0.31	99.50±3.33	120.16±4.00
	10	Chromate	8.84±0.30	2.65±0.12	14.42±0.48	25.91±0.86	3.11±0.13	9.93±0.34	19.72±0.66	23.72±0.80	11.71±0.40	68.19±2.28	94.10±3.12
		Dichromate	8.73±0.31	1.03±0.06	25.62±0.86	35.38±1.21	5.61±0.22	10.62±0.36	26.63±0.90	54.63±1.82	8.05±0.28	105.55±3.52	140.93±4.68
		Chromic	2.42±0.11	1.42±0.07	10.23±0.36	14.07±0.49	3.59±0.14	10.42±0.35	20.47±0.72	45.01±1.53	6.35±0.23	85.84±2.87	99.91±3.33
	50	Chromate	5.80±0.22	2.33±0.11	12.35±0.43	20.48±0.73	2.24±0.09	9.98±0.34	18.56±0.66	55.97±1.89	9.32±0.33	96.07±3.21	116.55±3.89
		Dichromate	6.39±0.24	2.20±0.10	38.26±1.29	46.85±1.60	6.62±0.23	10.20±0.36	27.68±0.95	55.26±1.88	11.02±0.38	110.78±3.69	157.63±5.25
		Chromic	3.26±0.14	3.77±0.14	23.18±0.79	30.21±1.04	3.84±0.15	8.05±0.28	19.30±0.65	32.11±1.09	5.56±0.21	68.86±2.31	99.07±4.33
55 10 days after 2nd irrigation with water.	0	0	3.70±0.15	2.88±0.13	17.48±0.60	24.06±0.85	7.02±0.24	12.71±0.35	14.93±0.59	69.38±2.32	8.61±0.30	112.65±3.75	131.71±4.59
	5	Chromate	5.43±0.20	2.63±0.12	33.25±1.13	41.31±1.43	3.23±0.14	14.48±0.46	16.50±0.60	83.97±3.13	7.05±0.26	125.23±4.17	166.45±5.59
		Dichromate	5.74±0.21	3.22±0.13	32.83±1.12	41.79±1.45	2.55±0.11	15.38±0.56	27.08±0.92	67.74±2.26	8.08±0.28	120.83±4.02	162.62±5.48
		Chromic	4.27±0.16	3.85±0.15	26.48±0.88	34.50±1.17	3.18±0.13	13.07±0.45	18.05±0.61	66.18±2.22	6.11±0.23	106.59±3.57	141.09±4.73
	10	Chromate	6.86±0.24	2.49±0.11	16.51±0.56	25.86±0.89	3.07±0.12	10.81±0.35	18.49±0.63	42.35±1.41	9.88±0.34	84.60±2.82	110.46±3.77
		Dichromate	7.13±0.25	2.88±0.12	38.89±1.31	48.90±1.96	5.54±0.20	12.69±0.43	18.22±0.62	68.60±2.30	5.84±0.22	110.89±3.69	159.79±5.64
		Chromic	3.79±0.15	2.45±0.10	14.61±0.50	20.85±0.72	13.73±0.46	14.86±0.49	19.94±0.69	62.21±2.12	8.84±0.31	109.58±3.65	130.43±4.35
	50	Chromate	4.42±0.17	3.31±0.14	23.73±0.81	31.56±1.11	2.56±0.10	13.60±0.45	15.15±0.52	99.26±3.11	8.96±0.32	139.53±4.65	171.09±5.77
		Dichromate	7.74±0.28	3.19±0.13	33.13±1.12	44.06±0.51	5.40±0.19	14.44±0.50	18.25±0.65	76.26±2.55	9.42.0.33	123.67±4.12	167.73±4.61
		Chromic	4.81±0.19	4.21±0.17	31.54±1.07	40.56±1.42	4.93±0.19	11.43±0.38	15.75±0.54	49.50±1.65	7.78±0.28	89.39±2.98	129.95±4.38
65 10 days after 3rd irrigation with water.	0	0	3.83±0.15	1.47±0.07	16.30±0.56	23.60±0.77	6.50±0.23	12.72±0.45	10.03±0.37	85.83±2.20	7.81±0.27	128.89±4.29	152.49±5.05
	5	Chromate	3.81±0.14	2.90±0.12	20.83±0.70	27.54±0.95	3.70±0.14	16.09±0.55	12.32±0.45	82.70±2.75	9.46±0.33	124.27±4.13	151.81±5.07
		Dichromate	4.25±0.17	3.06±0.13	23.54±0.80	30.85±1.08	3.15±0.13	17.61±0.61	29.15±0.99	83.83±2.79	8.95±0.31	142.69±4.75	173.54±5.81
		Chromic	4.10±0.16	3.51±0.14	16.66±0.57	24.27±0.86	2.75±0.12	15.74±0.54	15.01±0.52	82.98±2.77	7.66±0.26	124.14±4.11	148.41±4.98
	10	Chromate	5.42±0.26	2.95±0.12	18.04±0.61	26.41±0.98	3.33±0.13	13.72±0.48	19.16±0.65	63.67±2.12	10.28±0.35	110.16±3.64	136.57±4.61
		Dichromate	5.07±0.19	3.89±0.15	27.77±0.94	36.73±1.26	5.32±0.19	14.00±0.49	15.78±0.56	72.13±2.39	5.85±0.22	113.08±3.77	149.81±5.07
		Chromic	4.17±0.17	3.17±0.13	29.62±1.00	36.92±1.29	4.01±0.15	18.77±0.64	18.43±0.65	75.93±2.55	10.09±0.34	127.23±4.24	164.15±5.50
	50	Chromate	3.26±0.14	3.26±0.13	13.75±0.47	20.27±0.75	2.77±0.11	15.68±0.56	16.60±0.58	121.53±4.04	9.50±0.33	166.08±5.46	186.35±6.22
		Dichromate	6.98±0.24	3.54±0.14	35.77±1.20	46.29±1.57	3.34±0.13	17.81±0.62	12.40±0.44	92.15±3.09	10.43±0.36	136.11±4.53	182.40±6.11
		Chromic	5.12±0.18	5.12±0.19	16.90±0.58	27.14±0.93	3.25±0.13	16.37±0.57	13.02±0.45	62.10±2.08	9.87±0.33	104.61±3.28	131.75±4.22

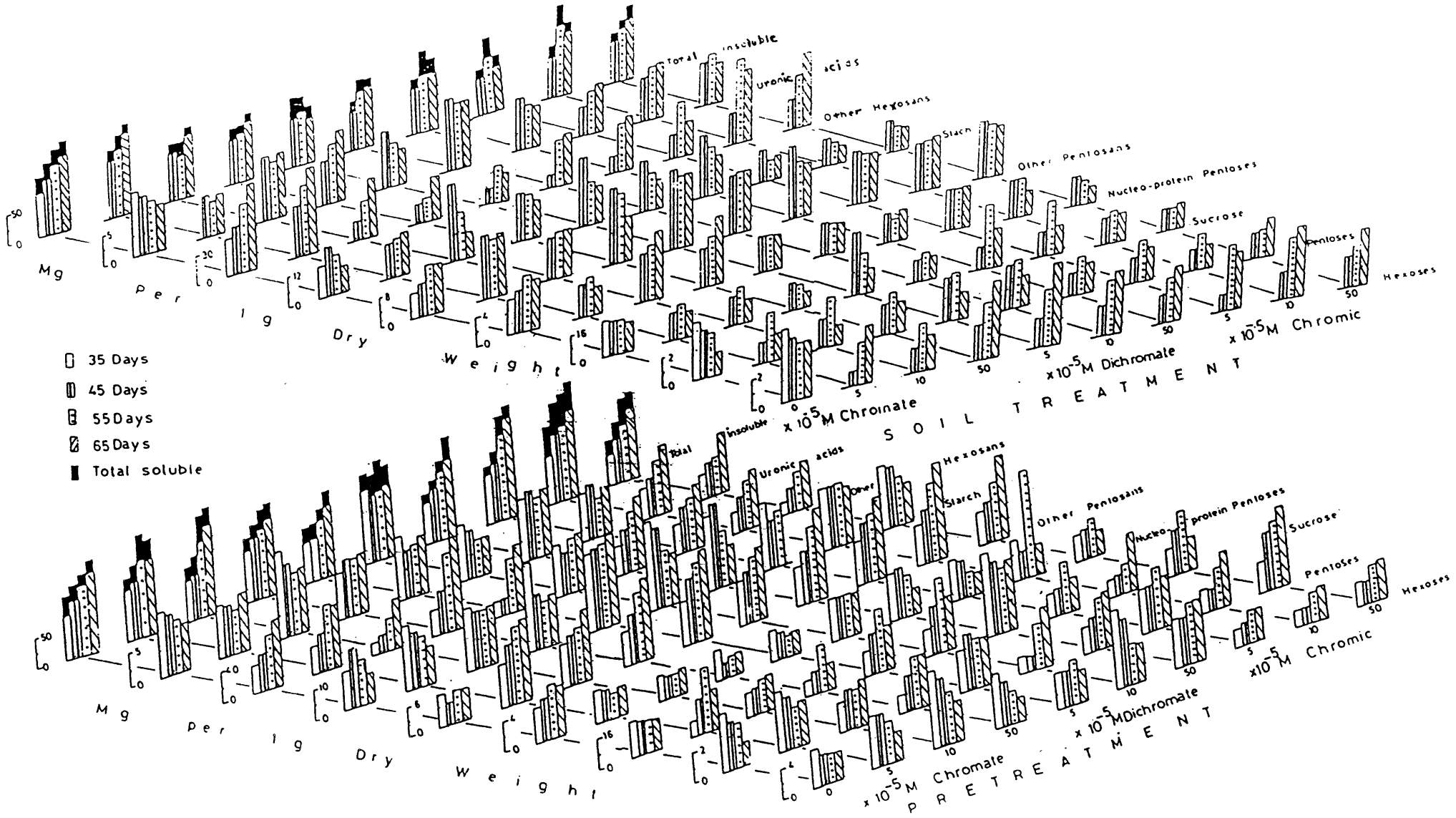


Fig (4) Comparative effects of previous leaf spray with various concentrations of different chromium ions with the effect of soil treatment with the same chromium ions levels on the carbohydrate content of leaves of Datura stramonium during the growth season (mg per 1g dry weight of leaves)

hexasons component, with little increase in soluble pentoses and other pentasons.

Table 4 b and Fig. 4 show that the first soil application equally lowered the total carbohydrate content of Datura stramonium leaves irrespective of type and/or concentration of chromium ions except chromate or dichromate, at 5×10^{-5} M concentration, that exerted almost no effect.

Repeated soil treatment with 5×10^{-5} M chromate ions negligibly affected the total carbohydrate content of the leaves whereas the larger doses induced almost similar inhibitory effects. On the other hand, though dichromate or chromic ions were less inhibitory or even slightly stimulatory to carbohydrate accumulation, after the second application, yet the third application of the ions favoured similar inhibitory effects to those of chromate ions.

Under all conditions, the drop was largely apparent in nucleoproteins, pentoses and other hexosons, followed by sucrose whereas other pentosans largely increased after the first treatment. Chromic ions were particularly effective in lowering the starch content of the leaves with minor effect on the sucrose level.

Phosphorus Content :

Table 5 a and Fig. 5 show that previous spraying with various concentrations of chromate ions favoured a better accumulation of phosphorus in the leaves; more prominently at the later stages of growth; soluble organic and/or other insoluble phosphorus participating in such event. Pretreatment with dichromate ions initiated the largest accumulation of phosphorus; particularly with progress of age of the plants whereby the whole increase was mainly in the soluble organic forms. Such effects were furthered with increasing the concentration of

Table 4b: Effect of soil treatment with various concentrations of different chromium ions on the carbohydrate content of leaves of Datura stramonium, during the growth season. (mg per 1 g dry weight).

Age in days	Concentration x 10^{-5} M	Chromium ion	Hexoses	Pentoses	Sucrose	Total soluble sugars	Nucleo-protein pentoses	Other pentosans	Starch	Other hexosans	Uronic acids	Total poly-saccharides	Total carbo-hydrates
35	0	0	5.02±0.18	3.19±0.15	18.90±0.66	27.70±0.97	4.58±0.19	6.59±0.24	12.45±0.44	36.54±1.23	10.51±0.35	70.67±2.40	98.38±3.32
45 10 days after 1st irrigation with chromium.	0	0	4.19±0.16	3.18±0.14	18.67±0.54	25.54±0.81	5.63±0.22	8.74±0.29	19.27±0.67	38.76±1.65	9.67±0.32	92.07±3.10	117.61±3.87
	5	Chromate	1.13±0.07	1.38±0.06	14.24±0.50	16.75±0.61	4.31±0.18	17.10±0.59	13.68±0.48	52.39±1.76	6.98±0.25	94.46±3.20	111.21±3.80
		Dichromate	1.88±0.09	2.82±0.19	33.77±1.14	37.47±1.20	4.77±0.19	19.96±0.65	27.74±0.94	17.18±0.59	9.22±0.32	78.87±2.68	116.34±3.95
		Chromic	1.18±0.07	1.73±0.08	12.58±0.45	15.49±0.58	5.30±0.20	13.93±0.49	12.85±0.45	23.75±0.80	4.84±0.17	60.67±2.10	76.16±2.67
	10	Chromate	1.79±0.09	1.94±0.09	15.45±0.52	19.18±0.70	6.44±0.24	10.77±0.38	31.46±1.06	19.18±0.65	10.42±0.36	78.27±2.65	95.55±3.36
		Dichromate	2.02±0.09	2.82±0.12	12.21±0.47	17.05±0.65	4.41±0.17	15.77±0.55	20.41±0.70	13.53±0.47	12.01±0.40	66.13±2.25	83.18±2.85
		Chromic	1.89±0.08	1.44±0.08	13.81±0.47	17.14±0.60	4.82±0.18	12.98±0.45	10.78±0.38	31.01±1.05	7.12±0.25	66.71±2.29	83.85±2.87
	50	Chromate	2.37±0.11	2.01±0.10	14.33±0.51	19.71±0.70	5.25±0.19	20.39±0.69	19.03±0.65	19.80±0.67	7.30±0.26	71.77±2.45	91.48±3.14
		Dichromate	1.85±0.09	1.47±0.07	12.59±0.43	15.91±0.57	3.96±0.16	19.11±0.66	24.52±0.85	18.01±0.61	8.81±0.30	74.41±2.52	90.32±3.06
		Chromic	2.02±0.10	1.72±0.08	12.28±0.42	16.02±0.58	3.82±0.15	15.08±0.53	12.78±0.44	27.80±0.94	7.04±0.24	66.52±2.25	82.54±2.81
55 10 days after 2nd irrigation with chromium.	0	0	3.70±0.09	2.88±0.13	17.48±0.57	24.06±0.80	7.02±0.26	12.71±0.44	14.93±0.52	69.38±2.34	8.61±0.28	112.65±3.80	136.71±4.59
	5	Chromate	2.76±0.12	3.22±0.14	17.76±0.62	23.74±0.85	5.03±0.19	14.73±0.51	14.93±0.53	68.49±2.29	5.45±0.21	108.63±3.66	132.37±4.48
		Dichromate	3.58±0.14	2.99±0.14	20.51±0.72	27.08±0.97	4.65±0.18	18.90±0.66	17.01±0.60	37.47±1.27	6.75±0.23	84.78±2.85	111.86±3.85
		Chromic	4.24±0.16	2.75±0.13	27.85±0.95	34.84±1.21	4.91±0.19	12.71±0.43	7.02±0.25	53.70±1.80	7.09±0.24	85.43±2.90	120.27±4.10
	10	Chromate	3.20±0.13	3.17±0.13	18.70±0.65	25.07±0.90	7.22±0.27	11.83±0.41	18.95±0.65	37.71±1.26	9.29±0.32	71.00±2.61	92.87±3.47
		Dichromate	3.35±0.14	3.07±0.12	15.20±0.54	21.62±0.78	4.02±0.16	15.90±0.55	14.21±0.50	46.55±1.56	10.83±0.35	91.61±3.13	113.43±3.89
		Chromic	3.92±0.15	2.26±0.11	15.97±0.55	22.15±0.80	4.74±0.18	12.83±0.44	8.47±0.29	81.70±0.93	8.46±0.29	116.20±3.91	148.35±4.73
	50	Chromate	3.69±0.15	2.62±0.12	11.96±0.47	18.27±0.69	6.41±0.25	17.94±0.62	17.20±0.10	23.12±0.75	9.52±0.33	74.19±2.31	92.46±2.97
		Dichromate	2.91±0.13	2.38±0.11	32.72±1.12	38.01±1.33	3.04±0.14	13.99±0.49	18.85±0.65	48.29±1.63	7.22±0.27	91.39±3.11	129.40±4.42
		Chromic	2.64±0.12	1.79±0.09	11.54±0.41	15.97±0.58	3.02±0.13	13.72±0.45	9.64±0.35	50.41±1.70	7.94±0.28	84.73±2.85	100.70±3.41
65 10 days after 3rd irrigation with chromium.	0	0	3.83±0.15	1.47±0.08	16.30±0.58	23.60±0.81	6.50±0.24	12.72±0.45	10.03±0.34	85.83±2.86	7.81±0.24	122.89±4.25	146.49±5.05
	5	Chromate	3.91±0.16	1.68±0.09	13.74±0.48	19.33±0.70	3.52±0.15	16.68±0.58	16.93±0.59	85.36±2.85	6.47±0.23	128.66±4.31	147.99±5.07
		Dichromate	5.35±0.20	1.82±0.09	14.40±0.50	21.57±0.78	4.65±0.18	19.16±0.85	14.87±0.51	28.65±0.98	5.79±0.21	73.12±2.50	94.69±3.25
		Chromic	3.72±0.15	2.19±0.11	14.17±0.51	20.08±0.75	5.44±0.20	12.88±0.43	8.92±0.31	34.93±1.20	7.70±0.27	69.87±2.35	89.95±3.06
	10	Chromate	2.38±0.11	1.41±0.07	11.50±0.41	15.29±0.55	8.87±0.30	12.51±0.41	10.42±0.35	58.65±1.95	10.61±0.36	100.97±3.41	116.26±3.93
		Dichromate	4.04±0.16	1.97±0.10	12.46±0.43	18.47±0.66	4.01±0.15	16.01±0.52	10.92±0.35	51.83±1.75	11.07±0.38	93.84±3.15	112.31±3.77
		Chromic	4.60±0.17	1.64±0.09	15.41±0.53	21.65±0.77	3.11±0.13	13.66±0.46	6.98±0.25	69.74±2.35	8.87±0.31	102.36±3.45	124.01±4.21
	50	Chromate	5.13±0.19	2.01±0.11	8.05±0.29	15.19±0.56	8.84±0.31	12.00±0.40	15.18±0.54	47.92±1.60	10.23±0.35	94.17±3.21	109.36±3.75
		Dichromate	3.60±0.15	2.51±0.12	19.93±0.71	26.04±0.92	1.90±0.08	14.16±0.46	14.94±0.52	54.45±1.82	6.99±0.25	92.44±3.12	118.08±4.04
		Chromic	3.69±0.15	2.49±0.11	13.62±0.46	19.80±0.70	2.07±0.10	12.77±0.42	8.96±0.31	71.18±2.37	6.41±0.24	101.39±3.41	121.19±4.14

Table 5a: Effect of previous leaf spray with various concentrations of different chromium ions on the phosphorus content of leaves of Datura stramonium, during the growth season of the produced seeds. (mg per 1 g dry weight of leaves).

Age in days	Concentration x 10^{-5} M	Chromium ion	Inorganic P	Soluble organic P	Total soluble P	RNA P	DNA P	Other insoluble P	Total insoluble P	Total P
35 Initials before irrigation with water.	0	0	0.92 ± 0.05	0.81 ± 0.05	1.73 ± 0.08	2.64 ± 0.11	0.80 ± 0.04	0.42 ± 0.04	3.86 ± 0.16	5.59 ± 0.21
	5	Chromate	1.04 ± 0.06	0.75 ± 0.04	1.79 ± 0.09	2.58 ± 0.10	1.61 ± 0.07	0.78 ± 0.05	4.97 ± 0.19	6.76 ± 0.25
		Dichromate	0.82 ± 0.05	1.77 ± 0.08	2.59 ± 0.11	1.00 ± 0.05	0.93 ± 0.05	0.47 ± 0.04	2.30 ± 0.11	4.89 ± 0.19
		Chromic	0.76 ± 0.04	0.73 ± 0.04	1.49 ± 0.07	1.38 ± 0.06	3.01 ± 0.11	0.39 ± 0.04	3.78 ± 0.16	5.27 ± 0.20
	10	Chromate	0.81 ± 0.04	1.21 ± 0.06	2.02 ± 0.08	2.04 ± 0.08	0.94 ± 0.05	0.83 ± 0.05	3.81 ± 0.16	5.83 ± 0.21
		Dichromate	1.03 ± 0.05	1.98 ± 0.09	3.01 ± 0.12	1.55 ± 0.08	0.73 ± 0.04	0.77 ± 0.05	3.05 ± 0.13	6.06 ± 0.22
		Chromic	0.84 ± 0.05	1.34 ± 0.06	2.18 ± 0.09	1.05 ± 0.05	1.07 ± 0.06	0.63 ± 0.04	2.75 ± 0.12	4.93 ± 0.19
	50	Chromate	1.32 ± 0.06	1.73 ± 0.08	3.05 ± 0.12	1.21 ± 0.06	0.63 ± 0.04	0.39 ± 0.04	2.23 ± 0.12	5.28 ± 0.21
		Dichromate	0.68 ± 0.04	1.39 ± 0.07	2.07 ± 0.09	0.94 ± 0.05	0.85 ± 0.05	0.69 ± 0.05	2.48 ± 0.12	4.55 ± 0.18
		Chromic	0.95 ± 0.05	0.66 ± 0.04	1.61 ± 0.08	1.32 ± 0.06	0.97 ± 0.05	0.33 ± 0.04	2.62 ± 0.13	4.23 ± 0.17
45 10 days after 1st irrigation with water.	0	0	1.00 ± 0.05	0.82 ± 0.05	1.82 ± 0.08	1.23 ± 0.07	1.17 ± 0.06	0.53 ± 0.04	2.93 ± 0.14	4.75 ± 0.18
	5	Chromate	1.38 ± 0.06	0.89 ± 0.05	2.27 ± 0.10	2.09 ± 0.09	1.71 ± 0.07	1.01 ± 0.06	4.81 ± 0.18	7.08 ± 0.25
		Dichromate	2.08 ± 0.08	2.04 ± 0.08	4.12 ± 0.15	1.37 ± 0.07	0.98 ± 0.05	0.62 ± 0.05	2.97 ± 0.13	7.09 ± 0.26
		Chromic	1.23 ± 0.06	0.62 ± 0.04	1.85 ± 0.09	2.33 ± 0.09	1.09 ± 0.05	0.50 ± 0.04	3.92 ± 0.16	5.77 ± 0.22
	10	Chromate	1.35 ± 0.07	1.01 ± 0.05	2.36 ± 0.10	2.06 ± 0.08	1.15 ± 0.06	1.25 ± 0.06	4.46 ± 0.17	6.82 ± 0.24
		Dichromate	1.22 ± 0.07	3.23 ± 0.12	4.45 ± 0.16	1.35 ± 0.07	1.02 ± 0.05	0.92 ± 0.05	3.29 ± 0.14	7.74 ± 0.27
		Chromic	1.53 ± 0.08	2.12 ± 0.09	3.65 ± 0.15	0.93 ± 0.05	0.86 ± 0.05	0.79 ± 0.05	2.58 ± 0.12	6.28 ± 0.24
	50	Chromate	2.11 ± 0.09	2.54 ± 0.10	4.65 ± 0.17	1.27 ± 0.06	0.96 ± 0.05	0.48 ± 0.04	2.81 ± 0.13	7.46 ± 0.26
		Dichromate	0.93 ± 0.06	2.37 ± 0.09	3.30 ± 0.13	1.95 ± 0.08	1.08 ± 0.06	0.78 ± 0.05	3.81 ± 0.16	7.11 ± 0.26
		Chromic	0.85 ± 0.05	0.73 ± 0.05	1.58 ± 0.08	1.68 ± 0.07	1.14 ± 0.06	0.74 ± 0.05	3.56 ± 0.15	5.14 ± 0.19
55 10 days after 2nd irrigation with water.	0	0	0.98 ± 0.05	1.30 ± 0.06	2.28 ± 0.10	1.21 ± 0.06	1.12 ± 0.06	0.83 ± 0.05	3.16 ± 0.14	5.44 ± 0.21
	5	Chromate	1.68 ± 0.07	0.79 ± 0.05	2.47 ± 0.10	1.31 ± 0.07	1.81 ± 0.05	1.62 ± 0.08	4.78 ± 0.18	7.25 ± 0.26
		Dichromate	2.27 ± 0.10	3.16 ± 0.12	5.43 ± 0.20	0.98 ± 0.06	1.15 ± 0.06	0.67 ± 0.05	2.80 ± 0.13	8.23 ± 0.29
		Chromic	1.47 ± 0.07	0.86 ± 0.06	2.33 ± 0.11	1.85 ± 0.08	1.14 ± 0.06	0.60 ± 0.04	3.59 ± 0.15	5.92 ± 0.22
	10	Chromate	1.49 ± 0.06	0.93 ± 0.06	2.42 ± 0.10	1.67 ± 0.07	0.96 ± 0.05	1.87 ± 0.07	4.50 ± 0.12	6.91 ± 0.25
		Dichromate	1.69 ± 0.08	4.59 ± 0.17	6.28 ± 0.22	1.24 ± 0.06	1.28 ± 0.06	1.39 ± 0.06	3.91 ± 0.16	10.19 ± 0.35
		Chromic	1.26 ± 0.06	3.21 ± 0.13	4.57 ± 0.17	0.81 ± 0.06	1.01 ± 0.05	0.86 ± 0.05	2.68 ± 0.13	7.25 ± 0.26
	50	Chromate	1.83 ± 0.08	1.31 ± 0.07	3.14 ± 0.13	1.67 ± 0.07	1.08 ± 0.05	0.81 ± 0.04	3.52 ± 0.14	6.70 ± 0.24
		Dichromate	1.29 ± 0.06	3.36 ± 0.13	4.65 ± 0.17	1.67 ± 0.07	0.97 ± 0.06	0.96 ± 0.05	3.60 ± 0.15	8.25 ± 0.29
		Chromic	1.00 ± 0.05	0.69 ± 0.05	1.69 ± 0.07	1.47 ± 0.06	0.94 ± 0.05	1.15 ± 0.06	3.56 ± 0.15	5.25 ± 0.20
65 10 days after 3rd irrigation with water.	0	0	1.48 ± 0.07	1.67 ± 0.08	3.15 ± 0.13	0.86 ± 0.05	1.16 ± 0.06	1.13 ± 0.06	3.15 ± 0.14	6.30 ± 0.23
	5	Chromate	1.97 ± 0.08	0.89 ± 0.06	2.86 ± 0;12	0.90 ± 0.05	1.75 ± 0.08	2;43 ± 0.09	5.08 ± 0.19	7.94 ± 0.28
		Dichromate	2.16 ± 0.09	7.10 ± 0.24	9.26 ± 0.31	1.07 ± 0.05	1.19 ± 0.06	0.82 ± 0.05	3.08 ± 0.14	12.34 ± 0.41
		Chromic	1.40 ± 0.06	0.81 ± 0.06	2.21 ± 0.10	1.71 ± 0;08	1.29 ± 0.06	0.73 ± 0.05	3.73 ± 0.15	5.94 ± 0.22
	10	Chromate	1.28 ± 0.06	0.89 ± 0.06	2.17 ± 0.10	1.17 ± 0.06	1.28 ± 0.06	2.00 ± 0.08	4.45 ± 0.17	6.62 ± 0.24
		Dichromate	1.86 ± 0.07	7.70 ± 0.26	9.56 ± 0.31	1.30 ± 0.06	1.47 ± 0.07	1.67 ± 0.06	4.44 ± 0.16	14.00 ± 0.45
		Chromic	1.07 ± 0.05	4.38 ± 0.16	5.45 ± 0.19	0.60 ± 0.04	0.96 ± 0.05	0.54 ± 0.04	2.10 ± 0.10	7.55 ± 0.27
	50	Chromate	1.67 ± 0.07	0.86 ± 0.06	2.53 ± 0.11	1.80 ± 0.08	3.67 ± 0.14	1.01 ± 0.05	6.48 ± 0.24	9.01 ± 0.31
		Dichromate	1.58 ± 0.07	5.95 ± 0.21	7.53 ± 0.26	1.51 ± 0.07	1.08 ± 0.06	0.83 ± 0.05	3.42 ± 0.14	10.95 ± 0.37
		Chromic	1.24 ± 0.06	0.86 ± 0.05	2.10 ± 0.09	0.98 ± 0.05	0.90 ± 0.05	1.64 ± 0.08	3.52 ± 0.14	5.62 ± 0.21

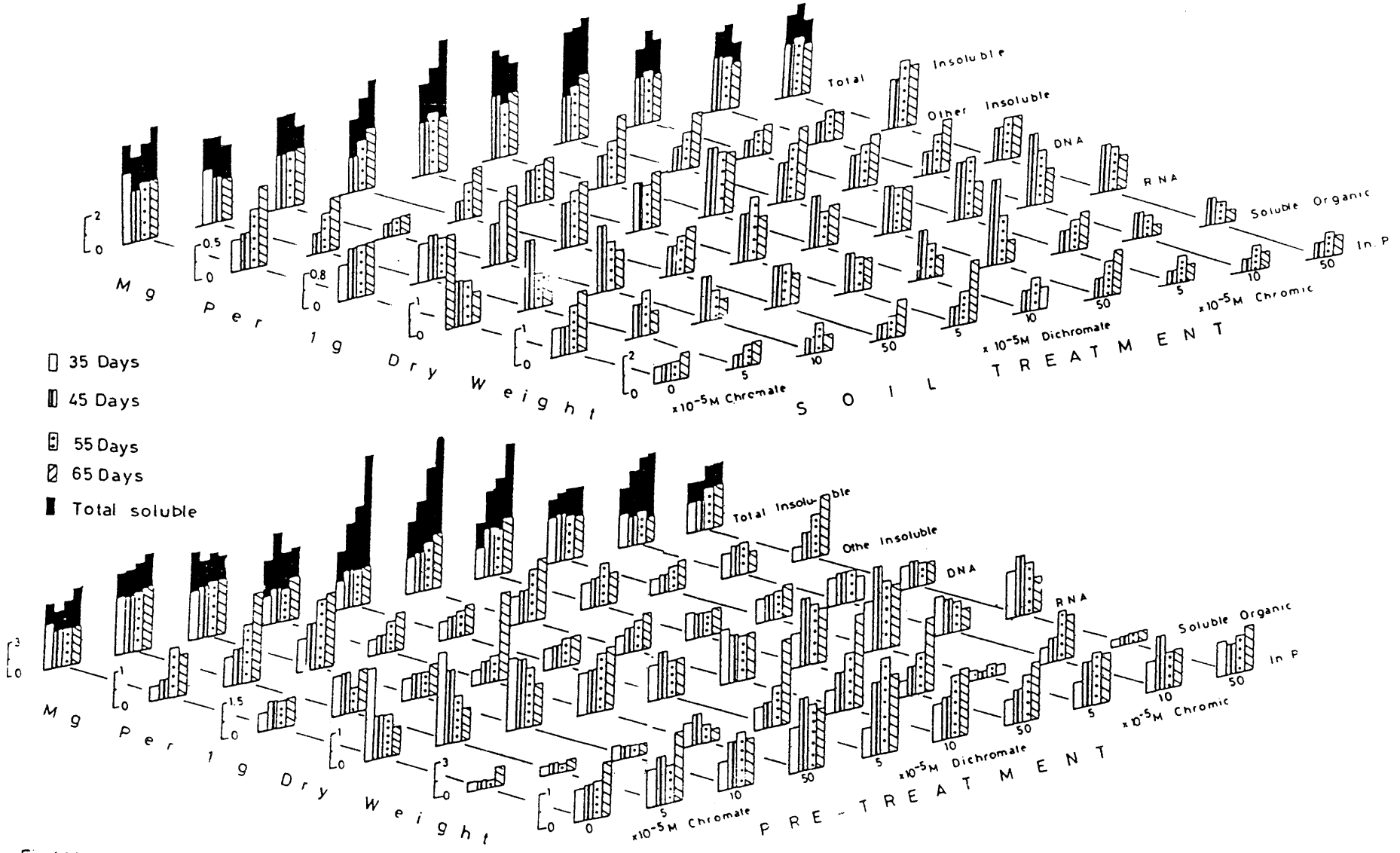


Fig.(5) Comparative effects of previous leaf spray with various concentrations of different chromium ions with the same chromium ions levels on the phosphorus content of leaves of Datura stramonium during the growth season (mg per 1 g dry weight of leaves)

dichromate ions to 10 x 10^{-5} M then slightly declined at the larger doses.

On the other hand, previous treatment with chromic ions seemed to exert minor effects on total phosphorus content except 10 x 10^{-5} M concentration where a slight increase was apparent mainly in the soluble organic forms; particularly towards the end of the experimental period.

Table 5 b and Fig. 5 show that the first soil treatment with either chromate or chromic ions seemed without effect on the various phosphorus components of Datura stramonium leaves whereas dichromate ions stimulated total phosphorus accumulations; particularly with application of the larger doses; the increase being mainly in the soluble organic component. The second soil treatment with chromate or chromic ions though hardly affected the total phosphorus content of the leaves yet the inorganic phosphorus level largely increased on the expense of soluble organic and/or other insoluble phosphorus. The second soil treatment with dichromate ions largely increased the phosphorus content as a result of increased inorganic phosphorus component; more prominently with large dose applications.

The third application of chromate or chromic ions to the soil favoured a drop in total phosphorus particularly from the soluble organic form. On the other hand, the third soil treatment with dichromate ions was still stimulatory to phosphorus accumulation as a result of increased levels of inorganic coupled with a drop in soluble organic phosphorus components. Such phenomenon faded with increased concentration of the ion but the increased inorganic phosphorus on the expense of soluble organic forms still prevailed.

Table 5b: Effect of soil treatment with various concentrations of different chromium ions on the phosphorus content of leaves of Datura stramonium, during the growth season. (mg per 1 g dry weight of leaves).

Age in days	Concentration x 10^{-5} M	Chromium ion	Inorganic P	Soluble organic P	Total soluble P	RNA P	DNA P	Other insoluble P	Total insoluble P	Total P
35	0	0	0.92 ± 0.05	0.81 ± 0.05	1.73 ± 0.08	2.64 ± 0.11	0.80 ± 0.04	0.42 ± 0.04	3.86 ± 0.16	5.59 ± 0.21
45 10 days after 1st irrigation with chromium.	0	0	1.00 ± 0.05	0.82 ± 0.05	1.82 ± 0.08	1.23 ± 0.07	1.17 ± 0.06	0.53 ± 0.04	2.93 ± 0.14	4.75 ± 0.18
	5	Chromate	0.76 ± 0.04	0.94 ± 0.05	1.70 ± 0.07	2.02 ± 0.08	0.87 ± 0.04	0.31 ± 0.03	3.20 ± 0.14	4.90 ± 0.19
		Dichromate	1.12 ± 0.05	1.13 ± 0.06	2.25 ± 0.09	1.41 ± 0.07	1.08 ± 0.05	0.47 ± 0.04	2.96 ± 0.14	5.21 ± 0.22
		Chromic	0.94 ± 0.05	0.66 ± 0.04	1.60 ± 0.07	1.66 ± 0.08	0.75 ± 0.04	0.26 ± 0.03	2.67 ± 0.13	4.27 ± 0.19
	10	Chromate	1.01 ± 0.05	1.30 ± 0.06	2.31 ± 0.09	1.88 ± 0.08	0.95 ± 0.05	0.20 ± 0.03	3.03 ± 0.13	5.34 ± 0.20
		Dichromate	1.22 ± 0.06	1.38 ± 0.06	2.60 ± 0.10	1.50 ± 0.07	1.55 ± 0.07	0.44 ± 0.04	3.49 ± 0.16	6.09 ± 0.23
		Chromic	0.83 ± 0.04	0.74 ± 0.04	1.57 ± 0.07	2.10 ± 0.08	0.53 ± 0.04	0.29 ± 0.03	2.92 ± 0.13	4.49 ± 0.18
	50	Chromate	0.91 ± 0.05	1.18 ± 0.06	2.09 ± 0.08	0.84 ± 0.05	1.03 ± 0.05	0.27 ± 0.03	2.14 ± 0.12	4.23 ± 0.18
		Dichromate	1.21 ± 0.06	2.43 ± 0.10	3.64 ± 0.13	1.33 ± 0.06	0.92 ± 0.05	0.36 ± 0.03	2.61 ± 0.12	6.25 ± 0.23
		Chromic	0.89 ± 0.04	0.80 ± 0.05	1.69 ± 0.07	1.41 ± 0.06	0.77 ± 0.04	0.71 ± 0.04	2.89 ± 0.13	4.58 ± 0.18
55 10 days after 2nd irrigation with chromium.	0	0	0.98 ± 0.05	1.30 ± 0.06	2.28 ± 0.10	1.21 ± 0.06	1.12 ± 0.00	0.83 ± 0.05	3.16 ± 0.14	5.44 ± 0.21
	5	Chromate	1.15 ± 0.05	1.27 ± 0.06	2.42 ± 0.09	0.94 ± 0.05	0.99 ± 0.05	0.54 ± 0.04	2.47 ± 0.12	4.89 ± 0.19
		Dichromate	1.81 ± 0.07	0.93 ± 0.05	2.74 ± 0.10	1.82 ± 0.07	0.96 ± 0.05	0.50 ± 0.04	3.28 ± 0.15	6.02 ± 0.22
		Chromic	1.52 ± 0.06	0.86 ± 0.05	2.38 ± 0.09	1.51 ± 0.07	0.94 ± 0.05	0.34 ± 0.03	2.79 ± 0.13	5.17 ± 0.20
	10	Chromate	1.57 ± 0.07	0.78 ± 0.05	2.35 ± 0.09	1.35 ± 0.06	1.40 ± 0.07	0.23 ± 0.03	2.98 ± 0.14	5.33 ± 0.21
		Dichromate	1.84 ± 0.07	0.94 ± 0.05	2.78 ± 0.11	0.97 ± 0.05	1.36 ± 0.06	0.61 ± 0.04	2.94 ± 0.14	5.72 ± 0.23
		Chromic	1.37 ± 0.06	0.59 ± 0.04	1.96 ± 0.08	1.49 ± 0.07	0.87 ± 0.05	0.40 ± 0.03	2.76 ± 0.13	4.72 ± 0.19
	50	Chromate	1.22 ± 0.05	1.13 ± 0.05	2.35 ± 0.09	1.08 ± 0.05	1.22 ± 0.06	0.51 ± 0.04	2.81 ± 0.13	5.16 ± 0.19
		Dichromate	1.99 ± 0.08	1.37 ± 0.06	3.36 ± 0.13	1.18 ± 0.05	1.26 ± 0.06	0.52 ± 0.04	2.96 ± 0.14	6.32 ± 0.25
		Chromic	1.31 ± 0.07	0.61 ± 0.04	1.92 ± 0.08	1.25 ± 0.06	0.90 ± 0.05	0.92 ± 0.05	3.07 ± 0.14	4.99 ± 0.21
65 10 days after 3rd irrigation with chromium.	0	0	1.48 ± 0.07	1.67 ± 0.08	3.15 ± 0.13	0.86 ± 0.05	1.16 ± 0.06	1.13 ± 0.06	3.15 ± 0.14	6.30 ± 0.23
	5	Chromate	1.26 ± 0.06	0.64 ± 0.04	1.88 ± 0.08	0.79 ± 0.04	0.86 ± 0.05	0.76 ± 0.05	2.41 ± 0.12	4.29 ± 0.18
		Dichromate	3.47 ± 0.13	0.88 ± 0.05	4.35 ± 0.16	1.18 ± 0.06	1.22 ± 0.06	0.58 ± 0.04	2.98 ± 0.14	7.33 ± 0.27
		Chromic	0.95 ± 0.05	1.06 ± 0.05	2.01 ± 0.08	1.03 ± 0.05	1.16 ± 0.05	0.39 ± 0.03	2.58 ± 0.12	4.59 ± 0.19
	10	Chromate	0.88 ± 0.05	0.53 ± 0.04	1.41 ± 0.06	1.10 ± 0.05	1.72 ± 0.07	0.23 ± 0.03	3.05 ± 0.13	4.46 ± 0.18
		Dichromate	2.20 ± 0.06	0.61 ± 0.04	2.81 ± 0.08	1.09 ± 0.05	1.40 ± 0.06	0.94 ± 0.05	3.43 ± 0.14	6.24 ± 0.20
		Chromic	0.93 ± 0.05	0.32 ± 0.03	1.25 ± 0.06	0.97 ± 0.05	1.16 ± 0.06	0.36 ± 0.03	2.49 ± 0.11	3.74 ± 0.15
	50	Chromate	1.98 ± 0.08	0.85 ± 0.04	2.83 ± 0.11	1.30 ± 0.06	1.40 ± 0.06	0.69 ± 0.04	3.39 ± 0.14	6.22 ± 0.23
		Dichromate	2.46 ± 0.10	0.65 ± 0.04	3.11 ± 0.12	1.20 ± 0.06	1.62 ± 0.07	0.78 ± 0.05	3.60 ± 0.16	6.71 ± 0.25
		Chromic	1.14 ± 0.06	0.36 ± 0.03	1.50 ± 0.07	0.96 ± 0.05	0.92 ± 0.05	0.85 ± 0.05	2.73 ± 0.12	4.23 ± 0.17

C- COMPARATIVE EFFECTS OF PREVIOUS LEAF SPRAY WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM IONS WITH THE EFFECT OF SOIL TREATMENT WITH THE SAME CHROMIUM IONS LEVELS ON THE ALKALOID CONTENT OF DATURA STRAMONIUM LEAVES DURING THE GROWTH SEASON.

C - COMPARATIVE EFFECTS OF PREVIOUS LEAF SPRAY WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM IONS WITH THE EFFECT OF SOIL TREATMENT WITH THE SAME CHROMIUM IONS LEVELS ON THE ALKALOID CONTENT OF DATURA STRAMONIUM LEAVES DURING THE GROWTH SEASON.

In this experiment, the leaves of 10 - 15 plants from each treatment were collectively dried in open air, in the shade, till constant weight. These were thoroughly ground and 5 replicates,1 g each, were extracted and analysed. Replicate samples were dried at 100^{o}C for calculation procedures.

R E S U L T S

Table 6 and Fig. 6 show that previous spraying with the various chromium salts favoured a lower total alkaloid content of leaves than that of controls; chromic ions were least whereas dichromate ions were most effective. Under all conditions, inhibition was furthered with rise of chromium ion concentration. With progress of age, the pretreated plants still accumulated lower amounts of alkaloids than the controls with minor differences due to type and/or concentration of chromium ion.

Similarly, application of chromium ions to soil was suppressive to alkaloid accumulation in Datura stramonium leaves; a phenomenon that was furthered with rise of concentration under all conditions chromate was least and chromic was most effective. Repeated soil treatment, with chromium ions hardly affected the alkaloid content of leaves, with less deleterious effects of chromic compared with chromate ions. By the end of the experiment, only the largest chromium dose seemed to be inhibitory whereas the lower concentrations almost exerted no effect compared with the controls.

Table 6: Comparative effects of previous leaf spray with various concentrations of different chromium ions with the effect of soil treatment with the same chromium ions levels on the total alkaloid content of Datura stramonium leaves, during the growth season. (mg per 1 g dry weight).

Age in days	Concentration x 10^{-5} M	Chromium ion	Total Alkaloid	Age in days	Concentration x 10^{-5} M	Chromium ion	Total Alkaloid
35 Initials before irrigation with water.	0	0	2.66 ± 0.13	35 Initials before irrigation with chromium.	0	0	2.66 ± 0.13
	5	Chromate	1.81 ± 0.10		5	Chromate	
		Dichromate	1.50 ± 0.10			Dichromate	
		Chromic	2.12 ± 0.11			Chromic	
	10	Chromate	1.78 ± 0.10		10	Chromate	
		Dichromate	0.92 ± 0.07			Dichromate	
		Chromic	1.63 ± 0.09			Chromic	
	50	Chromate	0.80 ± 0.07		50	Chromate	
		Dichromate	0.95 ± 0.07			Dichromate	
		Chromic	1.14 ± 0.08			Chromic	
40 5 days after 1st irrigation with water.	0	0	1.92 ± 0.10	40 5 days after 1st irrigation with chromium.	0	0	1.92 ± 0.10
	5	Chromate	1.30 ± 0.08		5	Chromate	1.82 ± 0.10
		Dichromate	1.20 ± 0.08			Dichromate	1.52 ± 0.09
		Chromic	1.85 ± 0.11			Chromic	1.41 ± 0.09
	10	Chromate	0.99 ± 0.06		10	Chromate	1.68 ± 0.10
		Dichromate	0.90 ± 0.07			Dichromate	1.39 ± 0.10
		Chromic	1.07 ± 0.08			Chromic	1.27 ± 0.08
	50	Chromate	1.86 ± 0.06		50	Chromate	1.55 ± 0.09
		Dichromate	0.75 ± 0.06			Dichromate	1.44 ± 0.07
		Chromic	0.95 ± 0.07			Chromic	1.16 ± 0.07
45 10 days after 1st irrigation with water.	0	0	1.91 ± 0.10	45 10 days after 1st irrigation with chromium.	0	0	1.91 ± 0.10
	5	Chromate	0.90 ± 0.07		5	Chromate	1.60 ± 0.08
		Dichromate	0.93 ± 0.06			Dichromate	1.02 ± 0.07
		Chromic	0.94 ± 0.07			Chromic	0.89 ± 0.06
	10	Chromate	0.79 ± 0.06		10	Chromate	1.17 ± 0.07
		Dichromate	0.97 ± 0.07			Dichromate	1.03 ± 0.07
		Chromic	0.74 ± 0.06			Chromic	0.91 ± 0.06
	50	Chromate	0.66 ± 0.06		50	Chromate	1.25 ± 0.08
		Dichromate	0.64 ± 0.04			Dichromate	0.90 ± 0.06
		Chromic	0.93 ± 0.06			Chromic	0.98 ± 0.06
55 10 days after 2nd irrigation with water.	0	0	1.70 ± 0.09	55 10 days after 2nd irrigation with chromium.	0	0	1.70 ± 0.09
	5	Chromate	0.85 ± 0.06		5	Chromate	0.87 ± 0.06
		Dichromate	0.86 ± 0.05			Dichromate	0.80 ± 0.05
		Chromic	0.91 ± 0.06			Chromic	1.61 ± 0.08
	10	Chromate	0.62 ± 0.05		10	Chromate	0.88 ± 0.05
		Dichromate	0.74 ± 0.06			Dichromate	0.94 ± 0.06
		Chromic	0.65 ± 0.05			Chromic	0.83 ± 0.05
	50	Chromate	0.47 ± 0.04		50	Chromate	0.97 ± 0.01
		Dichromate	0.54 ± 0.04			Dichromate	0.63 ± 0.04
		Chromic	0.73 ± 0.05			Chromic	0.81 ± 0.05
60 5 days after 3rd irrigation with water.	0	0	1.24 ± 0.06	60 5 days after 3rd irrigation with chromium.	0	0	1.24 ± 0.06
	5	Chromate	0.61 ± 0.04		5	Chromate	0.93 ± 0.05
		Dichromate	0.84 ± 0.05			Dichromate	0.96 ± 0.06
		Chromic	0.91 ± 0.05			Chromic	0.91 ± 0.05
	10	Chromate	0.48 ± 0.04		10	Chromate	0.98 ± 0.06
		Dichromate	0.64 ± 0.04			Dichromate	0.80 ± 0.05
		Chromic	0.51 ± 0.04			Chromic	0.81 ± 0.05
	50	Chromate	0.42 ± 0.04		50	Chromate	0.64 ± 0.04
		Dichromate	0.45 ± 0.04			Dichromate	0.52 ± 0.04
		Chromic	0.51 ± 0.04			Chromic	0.91 ± 0.06
65 10 days after 3rd irrigation with water.	0	0	0.97 ± 0.05	65 10 days after 3rd irrigation with chromium.	0	0	0.97 ± 0.06
	5	Chromate	0.42 ± 0.04		5	Chromate	0.85 ± 0.05
		Dichromate	0.63 ± 0.04			Dichromate	0.94 ± 0.05
		Chromic	0.81 ± 0.04			Chromic	0.81 ± 0.05
	10	Chromate	0.37 ± 0.03		10	Chromate	0.82 ± 0.05
		Dichromate	0.44 ± 0.03			Dichromate	0.63 ± 0.09
		Chromic	0.35 ± 0.03			Chromic	0.89 ± 0.04
	50	Chromate	0.35 ± 0.03		50	Chromate	0.42 ± 0.04
		Dichromate	0.35 ± 0.03			Dichromate	0.41 ± 0.03
		Chromic	0.32 ± 0.03			Chromic	0.73 ± 0.04

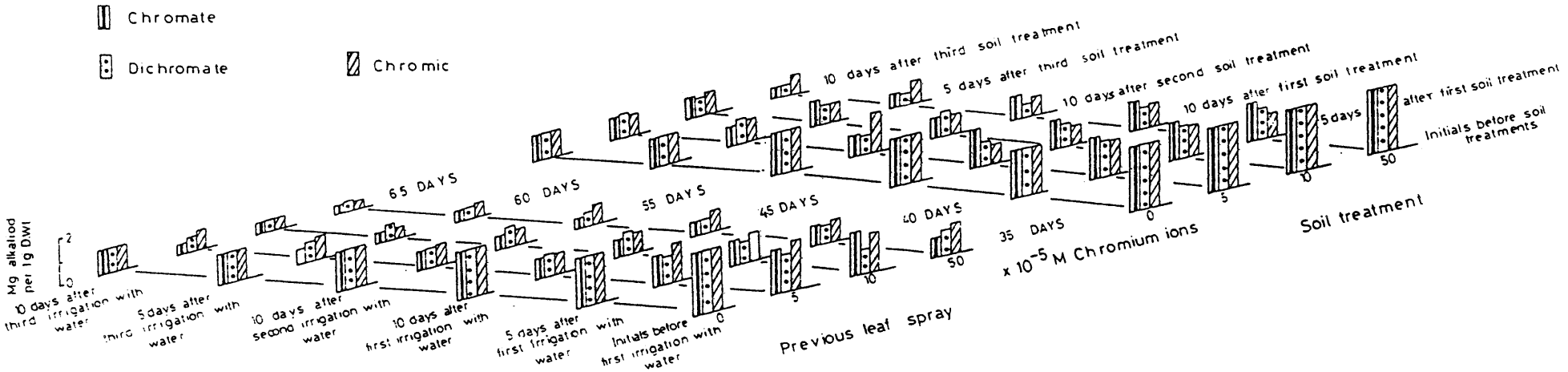


Fig.(6) Comparative effects of previous leaf spray with various concentrations of different chromium ions with the effect of soil treatment with the same chromium ions levels on the total alkaloic content of Datura stromonium leaves, during the growth season. (mg per 1 g dry weigh of leaves)

Table 7 and Fig. 7 show that valeroidine,meteloidine, hyocyamine,hyosine and tropine were early formed within the control leaves followed by oscine and tigloidine whereas belladonine started to accumulate at later stages of growth. Previous leaf spray with chromium ions remarkably increased the tropine content with a severe drop in hyoscine, particularly at later stages of growth. Towards the end of the experimental period, the large doses of dichromate depleted the leaves of their tropine content with comparatively larger accumulation of tigloidine, valeroidine, meteloidine or hyoscyamine.

Furthermore, it seems that previous leaf spraying with the chromium salts delayed the accumulation of alkaloid in the second progeny lest unknown II, hyosine and tropine. In most cases the alkaloid content was restricted to a fewer number of components compared with the controls.

Similar trends were also observed following application of the chromium ions to the soil. Towards the end of the season, unknown III, valeroidine, meteloidine, and hyoscine were most abundant whereas tropine and the rest of the alkaloids may be missing particularly with dichromate application.

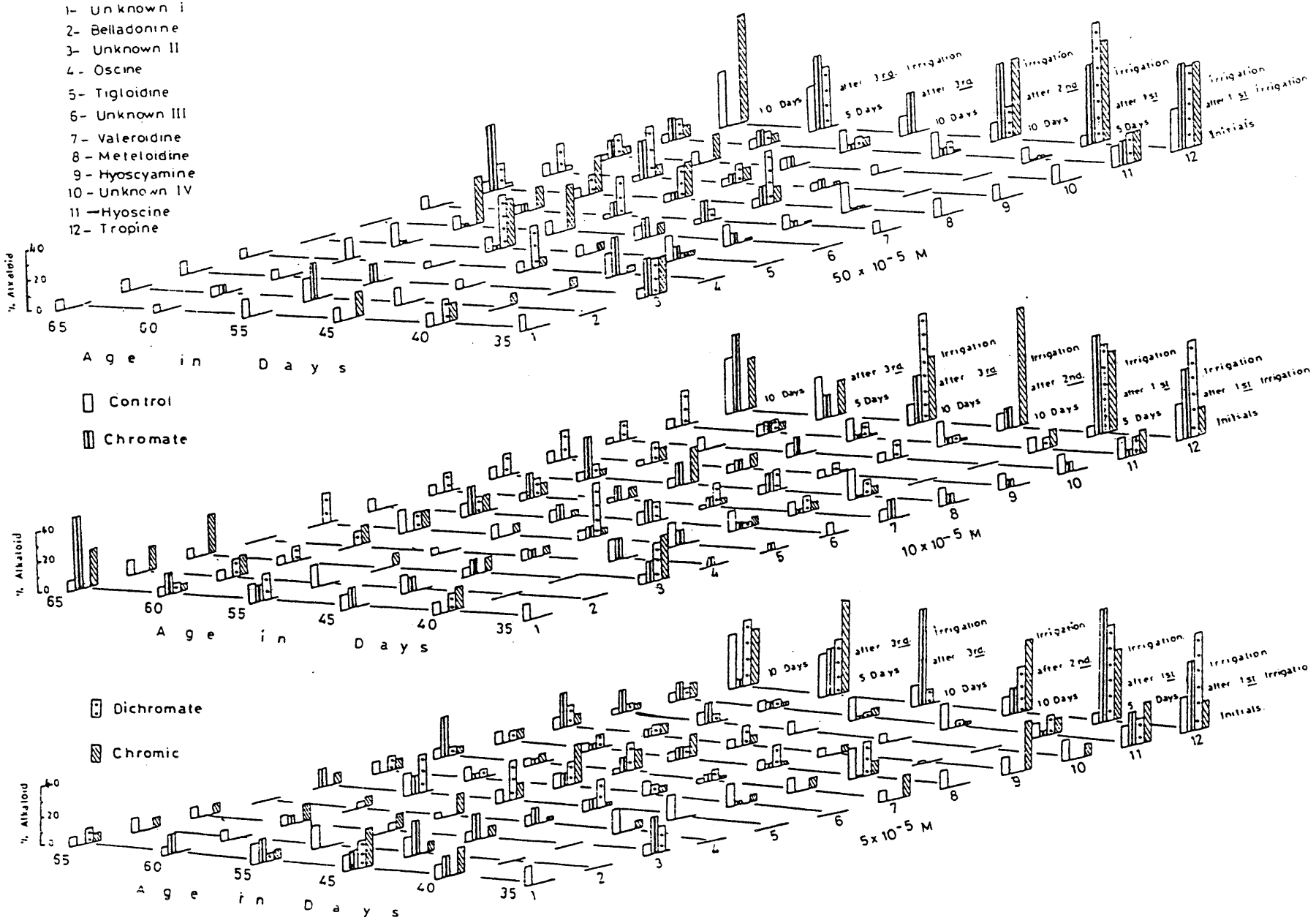


Fig.(7a) Effect of previous leaf spray with various concentrations of different chromium salts on the percentage alkaloid content of Datura stramonium leaves, of the first progeny

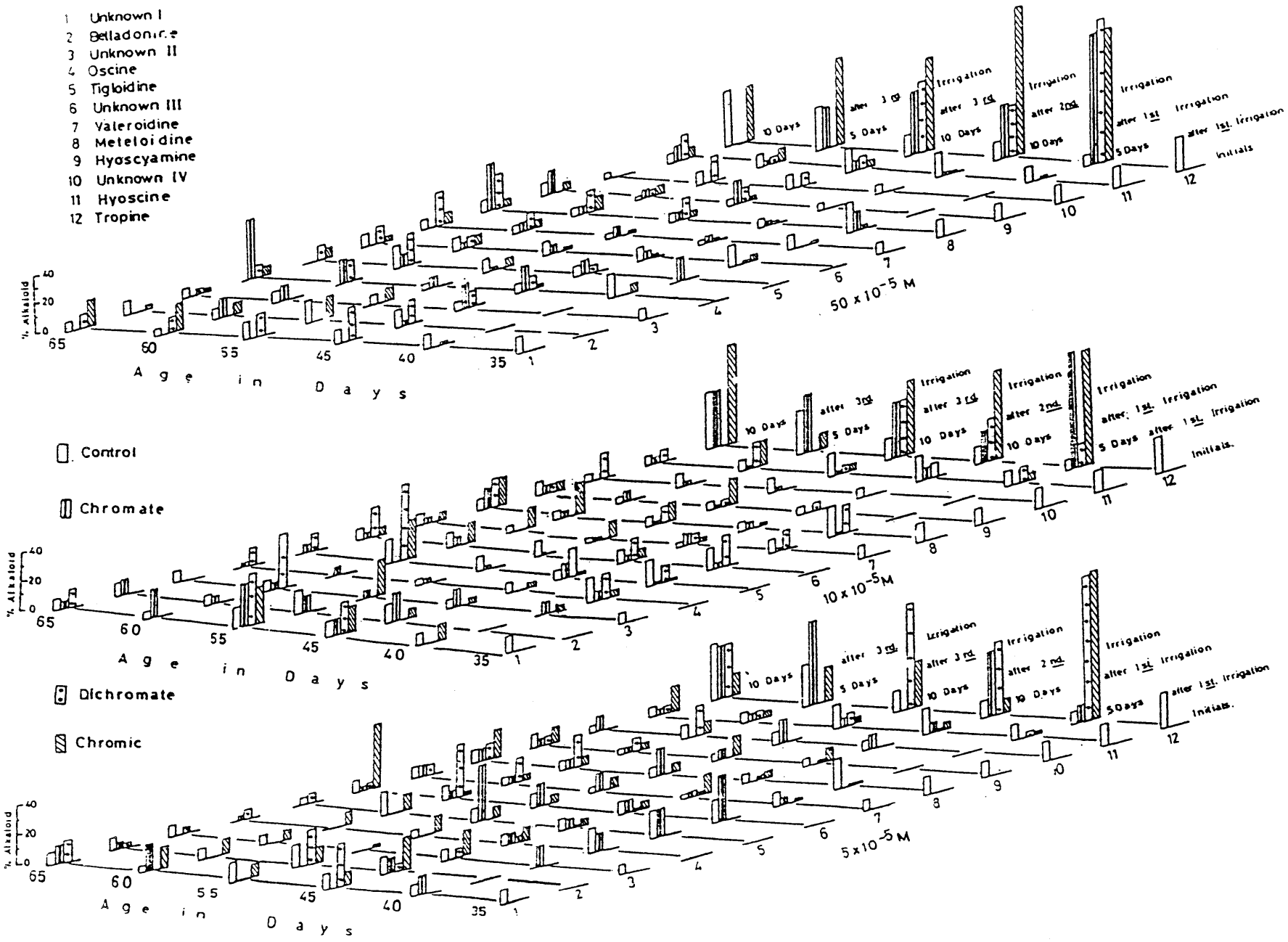


FIG. (7b) EFFECT OF IRRIGATION WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM SALTS ON PERCENTAGE ALKALOID CONTENT OF DATURA STRAMONIUM LEAVES.

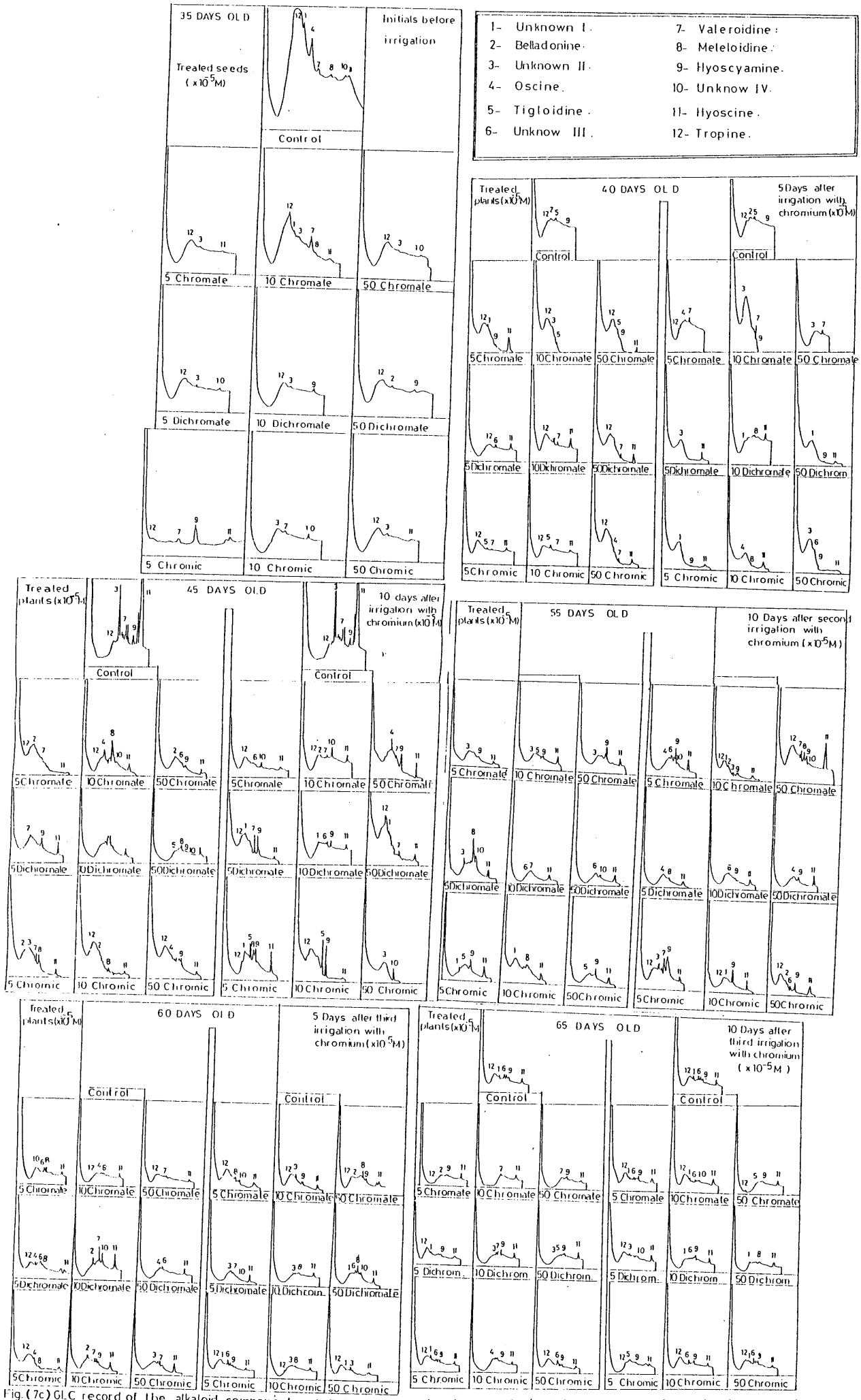


Fig. (7c) GLC record of the alkaloid components of Datura stramonium leaves, obtained from progeny of previously sprayed plants with chromium salts as well as those produced after soil treatment with the same levels of chromium ions.

D- COMPARATIVE EFFECTS OF PREVIOUS LEAF SPRAY WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM IONS WITH THE EFFECT OF SOIL TREATMENT WITH THE SAME CHROMIUM ION LEVELS ON SEED YIELD BY *DATURA STRAMONIUM* PLANTS.

D - COMPARATIVE EFFECTS OF PREVIOUS LEAF SPRAY WITH VARIOUS CONCENTRATIONS OF DIFFERENT CHROMIUM IONS WITH THE EFFECT OF SOIL TREATMENT WITH THE SAME CHROMIUM ION LEVELS ON SEED YIELD BY DATURA STRAMONIUM PLANTS.

Table 8 and Fig. 8 show that previous spraying with low concentration of the chromium ions insignificantly affected the weight of both components of the capsule. Chromate or chromic ions seemed to increase the weight of 100 seeds whereas dichromate ions seemed without effect. Soil treatment with the same doses highly stimulated the gain in dry weight of both components of the fruits; chromate ions being most whereas dichromate being least effective. Still, dry weight per unit seed largely increased with application of chromate but was indifferent to dichromate or chromic ions.

Previous spraying with larger chromium ion doses slightly, if at all, affected the dry weight of the capsule components except chromic ions which caused an appreciable increase that was furthered with rise of concentration of the ion to 50×10^{-5} M. Increased dose of chromiun ions in the irrigation water progressively attenuated dry weight of the capsule components; more prominently with addition of the anionic forms.

Under all conditions, soil treatment favoured better gain of dry weight by the capsule, than previous leaf spraying. Meanwhile, the ratio of seeds, per capsule, was almost unaffected by any treatment whereas chromic ions increased the weight of 100 seeds.

Table 8 : Comparative effects of previous leaf spray with various concentrations of different chromium ions with the effect of soil treatment with the same chromium ions levels on fruit and seed weight of Datura stramonium.

Concentration x 10^{-5} M	Chromium ion	Treat-ment	Wt.of 100 seeds (Mg)	% seeds in capsule	Empty capsule (Mg)	Seeds per capsule (Mg)	Mean fruit weight (Mg)
0	0	Spray	478.5±8.0	63.3	106.9± 3.8	182.2± 6.1	289.1± 9.6
		Soil	478.5±8.0	63.3	106.9± 3.8	182.2± 6.1	289.1± 9.6
5	Chromate	Spray	511.8±8.4	62.5	121.0± 4.3	201.8± 6.7	322.8±10.7
		Soil	553.8±9.2	68.3	315.0±11.5	677.5±22.9	992.5±33.8
	Dichromate	Spray	478.5±7.9	61.9	109.5± 4.0	177.6± 5.9	287.1±10.2
		Soil	462.5±7.7	62.5	164.7± 5.9	274.4± 9.1	439.1±14.6
	Chromic	Spray	568.8±9.8	58.9	128.7± 4.7	184.2± 6.2	312.9±10.8
		Soil	497.5±8.3	58.9	237.5± 8.6	313.1±10.3	550.6±18.4
10	Chromate	Spray	482.0±8.1	57.2	161.0± 5.8	215.6± 7.3	376.6±12.5
		Soil	487.5±8.2	59.4	154.7± 5.5	226.3± 7.5	381.0±13.1
	Dichromate	Spray	442.5±7.5	63.6	105.6± 3.7	184.4± 6.3	290.0± 9.8
		Soil	495.0±8.2	60.1	183.9± 6.6	276.8± 9.1	460.7±15.3
	Chromic	Spray	475.5±7.8	63.3	175.1± 6.4	302.0±10.1	477.1±16.0
		Soil	533.8±8.8	62.1	291.0±10.4	467.8±15.5	768.8±25.4
50	Chromate	Spray	481.3±8.0	62.2	114.9± 4.1	189.3± 7.0	304.2±10.1
		Soil	452.5±7.5	63.6	144.6± 5.6	252.4± 8.4	393.0±13.2
	Dichromate	Spray	507.0±8.3	62.5	122.3± 4.4	203.4± 6.7	325.7±11.3
		Soil	500.0±8.4	64.0	176.2± 6.5	312.4±10.4	488.6±16.5
	Chromic	Spray	476.3±7.9	62.5	227.5± 8.3	378.8±11.5	606.3±20.4
		Soil	523.8±8.7	64.6	275.0±10.0	501.6±16.5	776.6±26.6

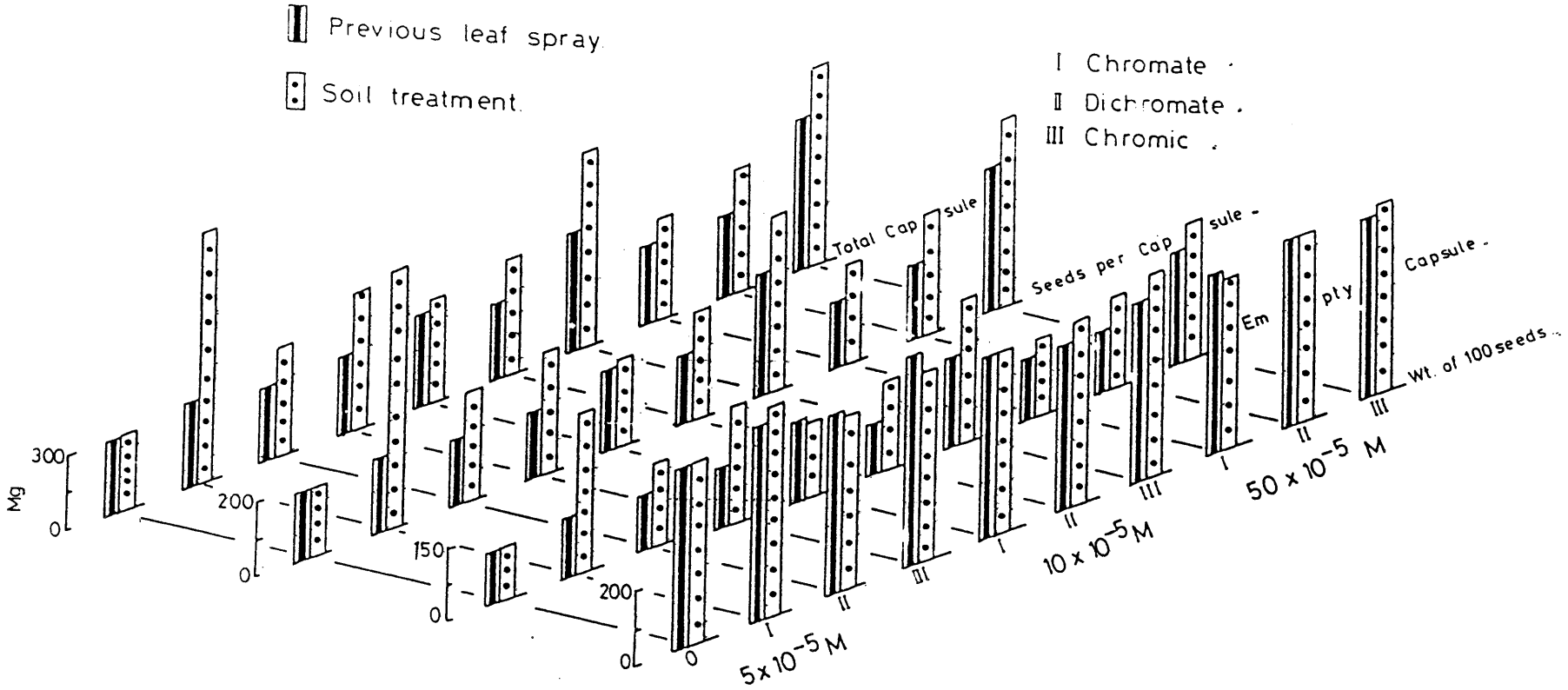


Fig.(8) Comparative effects of previous leaf spray with various concentrations of different chromium ions with the effect of soil treatment with the same chromium ions levels on fruit and seed weight of Datura stramonium.

PART III

A- DISCUSSION.

B- SUMMARY.

C- REFERENCES.

PART III

DISCUSSION

The results of this investigation clearly show the persistant inhibitory effects of previous spraying the Datura plant leaves with various concentrations of chromium salts on leaf area of the progeny. Still chromate and dichromate were more effective than chromic ions particularly at the early stages of growth.

In the meantime though the previous leaf spraying slightly, if at all, affected the fresh weight gain, yet such treatment still enhanced dry weight gain by the produced leaves particularly towards the end of the experimental period. Chromic ions were most whereas dichromate ions were least effective in this respect.

These observations indicate the inherent persistant effect of the sprayed chromium ions on cell expansion and/or cell division leading to smaller leaf area coupled with increased anabolic metabolism leading to increased dry weight of such leaves.

In this connection it may be mentioned that Fukunaga et al. (1981) showed that all tested heavy metals inhibited growth of Sacchoromyces cerevisiae and the surviving deploid cells were reduced at 10^{-2} - 10^{-4} M. Mitotic gene conversion was induced by Co, Cr, As and Cd ions and mitotic crossing over in convertants was observed by treatment with Cr, Mn, Ni and Cd ions. Roy and Mukherji (1982) showed that treating mung beans with chromate or chromic ions inhibited hypocotyl elongation and fresh and dry weight increase.

On the other hand, the absorption of chromate or chromic ions through the root system of 5 - weeks old plants greatly

stimulated cell division and/or cell expansion as well as anabolism thus leading to the observed significant increase in leaf area, fresh and dry weight of the leaves. Increased concentration of chromate alleviated such effects whereas chromic larger doses slightly counteracted its stimulatory effects. On the other hand, dichromate ions though limited the leaf area and fresh weight gain, more prominently with application of the larger doses, yet the dry weight gain was still higher than the controls.

Repeated dosage of chromic ions had the same stimulatory effects whereas repeated dosage of dichromate ions was still inhibitory to leaf area with minor effects on fresh and dry weight. On the other hand, repeated dosage of dichromate alleviated its stimulatory effects particularly with administration of the larger doses.

These observations confirm the earlier findings (Fiussello and Novo, 1976) that chromate was less deleterious to higher plants than dichromates whereas chromic ions were stimulatory Roy and Mukherji (1982) reported potassium dichromate to be more toxic to mung beans than chromic sulphate. Still Levis and Majone (1981) showed that Cr (VI) compounds particularly potassium dichromate and zinc yellow differentially inhibit macromolecular synthesis in Syrian hamster fibroblast (BHK) cells, especially that of DNA.Cr (III) compounds had very low toxicity. On the contrary chromic chloride was reported to stimulate RNA synthesis when incubated with DNA or chromatin (Okada et al., 1981). Oshida et al. (1981) showed that Cr^{+6} totally suppressed reproduction of polychaetes at 100 ug/ml concentration whereas Cr^{3+} had no adverse effects at 400 ug/ml. Trivalent chromium was reported as an essential trace element for birds and man (Steele and Rosebrough, 1979; Ryan and Hastings Vogt, 1977;

Okada et al., 1981). Still chromic ions are considered an indispensable micro element (Bertrand and DeWolf, 1968) improving the yield and growth responses of several crop plants including potato and grapes as well as silage yield (Evanylo and Barker, 1981).

In the meantime, it seems that leaf spray is more effective in the toxic action of chromium ions on leaves than translocation of the same ions via the root system. Chromate ions were reported to be absorbed freely by barley roots (Shewry and Peterson, 1975) but little is transported to the shoot. Skeffington et al. (1976) claimed that chromate uptake was active whereas chromic uptake was passive, indicating differences in mechanisms of absorption of the two ions. Wallace et al. (1977) noticed that under culture experiments, chromium ions tended to concentrate in roots of bush beans with a decreasing gradient to stems and leaves. Lahouti and Peterson (1979) further showed that several crop plants accumulate Cr^3 or Cr^6 from nutrient solutions and retained approximately 98% of the element in the roots. Under the same conditions, roots contained more of Cr^3 than of Cr^6 whereas the reverse applied to the shoots.

The results further show that although previous spraying hardly affected pigments content of leaves, during the early stages of growth of the progeny, yet with progress of age chromate and dichromate severely attenuated chlorophyll a and chlorophyll b as well as carotenoid content whereas chromic ions were stimulatory. This shortage of pigmentation indicates earlier senescence of the leaves.

On the contrary, application of chromium salts to the soil reduced pigmentation of the leaves; dichromate producing the highest and chromic ions exerting the least effect particularly at their larger doses. The second treatment counteracted

the inhibitory effects of the three ions when supplemented at 10×10^{-5} M particularly chromic ion that continued to accelerate pigment accumulations after the third treatment whereas the hexavalent anionic forms were very suppressive.

These differences in behaviour of chlorophyll content might be attributed to the fact that chromium, in the soil, have interfered with the absorption and translocation of other elements particularly potassium, magnesium and iron.

In this connection it may be mentioned that Rusko (1968) reported increased chlorophyll content in grape leaves following chromium application. He attributed such increase to more stability of the plastids in presence of the ion that exerted a protective action against chlorophyll degradation. Mukherji and Roy (1978) reported that when applied alone or in combination with IAA, potassium dichromate completely inhibited cell enlargement of wheat coleoptile sections at 5×10^{-3} M or even less. Lahouti and Peterson (1979) reported greater proportions of soluble chromium in plants supplied with Cr^{6} than those supplied with Cr^{3}. Turner and Rust (1971) showed that 0.5 ppm anionic chromium lowered the uptake of potassium, iron, phosphorus and manganese in roots. In soils, 0.6 ppm chromium interfered with the accumulation of calcium, potassium, magnessium, phosphorus, boron and copper.

According to Oberlaender and Roth (1978) potassium and phosphorus uptake and translocation were inhibited by seven heavy metals including chromium. Translocation of both nutrients into the shoots was more inhibited than uptake into the roots. Smirnov (1978) showed that teratogenic concentrations of chromium stimulated polyphenol oxidase activity leading to accumulation of anomalous metabolites of phenol and quinoid nature. Roy and Mukherji (1982) showed that the activity of catalase, peroxidase, IAA-oxidase, ascorbic acid oxidase and dehydrogenase increased in response to supplementation of chromium to mung been seedlings.

Nitrogen analysis revealed that previous spray of Datura leaves with the various chromium ions resulted in a lower amounts of accumulated nitrogen in the leaves of the progeny; a phenomenon that was almost alleviated by the end of the experimental period due to the gradual decrease in nitrogen content of control leaves, with progress of age. In other words, the leaves of the new offspring had almost a consistent low nitrogen content that was indifferent to progress of age. This indicates that chromium might have interfered with one site in the pathways of nitrogen metabolism.

Sakurai et al. (1978) reported that hexavalent chromium was reduced to the trivalent chromium by sulphydryl containing proteins viz.as bovine albumin and haemoglobin. If not completely reduced to Cr (III) by extracellular and endoplasmic constituents, Cr (VI) could reach the cell nucleus and directly interact with DNA (Tamino et al., 1981).

Mukherji and Roy (1978) reported that coincident with growth inhibition of mung bean seedlings by dichromate, there was a difference in the pattern of distribution of sugar and nitrogen in the embryo and cotyledons. Roy and Kukherji (1982) revealed an increased level of soluble proteins in mung bean seedlings following treatment with either dichromate or chromic ions.

Apart from these fluctuations, the ratio of insoluble nitrogen was greater in the treated than control leaves, during the early stages of growth but was reversed by the end of the experimental period. This indicates enhanced protein synthesis during the early stages of growth accompanied by early or rapid senescence towards the end of the growing season.

Application of the various chromium salts to the soil had the same drastic inhibitory effects on nitrogen accumulation in the leaves; a phenomenon that remained apparent with repeated treatment. This shows the slower rate of nitrogen translocation to the leaves. Still rapid translocation from the leaves to the root may still be operating.

In the meantime, the first soil application enhanced insoluble nitrogen accumulation as could be observed from its higher ratios compared with the control samples. Repeated soil treatments inhibited such process.

Such similarity in response of nitrogen metabolism in Datura leaves to the chromium ions regardless mode of application confirms the previous suggestion that chromium (anionic or cationic) acted upon one and same site.

It may be recalled that Levis et al. (1978), working on hamster fibroblasts and human epithelial - like cells, showed that the cytotoxic effects of chromium were attributed to the action of Cr^{6+} at the plasma membrane level on the mechanisms involved in nucleoside uptake and interactions of Cr^{3+} at the intracellular level with nucleophilic targets on the DNA molecule. Levis and Majone (1981) showed that chromium accumulated in the cells after treatment with Cr^{3+} was most probably bound to the cell membrane whereas some of the Cr^{6+} was transported through the cell membrane and reduced in the cell nucleus.

Yamamoto et al. (1981) working with potassium dichromate and Wu and Wada (1981 a) using Cr^{+3} showed that both ions combined with low molecular weight organic substances that could be traced in several mammalian organs. These compounds were more persistant than the rapid disappearing high molecular weight combinations. These were idintified as anionic

organic complexes which contained Cr (III), amino acids and other UV absorbable components of molecular weight 1600 and 2600. Wu and Wada (1981 b) showed that these organic chromium complexes were less than those of either dichromate or chromic ions and play an important role in the detoxification and excretion of chromium.

The results of this investigation further showed that previous spraying with chromate ions seemed to have little or minor effect on the total carbohydrate content of the leaves of the progeny whereas dichromate enhanced while chromic ions inhibited total carbohydrate accumulation particularly with application of larger doses and/or repeated spraying. If these observations were coupled with minor effects on pigmentations though nitrogen accumulation was lesser than the control one might attribute these observations to inhibited nitrogen metabolism following chromate spraying that was furthered with applications of dichromate whereas chromic ions inhibited photosynthesis.

Warren et al. (1981) reported that Cr (III) in the proper ligand environment can have considerable genetic toxicity and could represent one of the several possible ultimate species in a mechanism for chromium mutagenesis and carcinogenesis.

In spite of this differences in response, the polysaccharide ratio seemed unaffected except with application of the largest dose of either chromate or chromic where a lower ratio was significant; an indication that phosphorylation mechanisms leading to polysaccharide synthesis were inhibited by such treatments; more prominently the dichromate ion. Apart from these fluctuations in the ratio of polysaccharides, the increased starch content of these leaves might lead to the suggestion that chromium ions retarded translocation of sugars

to the other parts of the plants. This could be confirmed by the increased sucrose content especially with dichromates.

Sastry and Tyagi (1982) showed that sublethal concentrations of Cr^{6+} increased blood glucose and lactic acid levels in a fresh water teleost fish. Liver glycogen was depleted but muscle content increased. Lactic dehydrogenase pyruvic dehydrogenase and succinic dehydrogenase increased indicating an increased rate of glycolysis.

Similarly irrigation with various concentrations of the different chromium salts seemed with minor inhibitory effects on the total carbohydrate content as well as the ratio of polysaccharides. If this is coupled with the reduced pigmentation, particularly with application of chromate or dichromate, as well as reduced nitrogen accumulation, one would attribute such carbohydrate behaviour to reduced photosynthetic rate as well as inhibited incorporation into organic nitrogen forms.

Repeated irrigation treatment inhibited carbohydrate accumulation more prominently after the third application. Since the loss of carbohydrates was mostly apparent in nucleoprotein pentoses followed by the other polysaccharides then we may conclude that repeated application of chromium ions inhibited RNA and DNA synthesis which in turn impaired the metabolic pathways for carbohydrate and/or nitrogen accumulation.

In this connection it may be mentioned that Chang and Broadbent (1981) showed that 50% reduction in carbon dioxide output by Yolo silt loam soil amended with alfalfa meal was best obtained by addition of chromium followed by cadmium then copper; 8.6 p.p.m. chromium caused 10% reduction whereas 27 p.p.m lead was required to produce the same effect. 10 ug/L Cr (VI)

exhibited an impaired oxygen transfer by the rainbow trout gills (Van der Putte and Part, 1982).

The results of this investigation further show that previous leaf spraying though slightly lowered the total phosphorus content of the leaves of the progeny, at the early stages of growth yet with lapse of time, phosphorus accumulations in the treated leaves exceeded that of the control plants, under all conditions, most of the fluctuations were in the soluble organic forms; indicating increased metabolic activity with minor effects on RNA and DNA. In other words, the deleterious effects of previous spraying on nitrogen and/or carbohydrate metabolism are not attributed to shortage of nucleoproteins but may be due to structural variations within the molecules controlling such metabolic processes.

On the other hand, supplementation of chromium salts in the irrigation water slightly lowered the total phosphorus content of the leaves with a tendency towards increased soluble organic phosphorus on the expense of the other insoluble phosphorus except for dichromate treatment that stimulated phosphorus accumulation mostly in the soluble organic form. Repeated application of chromium via the soil hardly affected the total phosphorus of the treated plants, thus leading to apparent reduction in phosphorus content of chromate-or chromic-treated plants whereas dichromate treatment appeared with negligable effects. Still the main fluctuations were in the soluble organic form.

This indicates that neither previous spraying nor absorption of chromium through the roots had an apparent effect on nucleoprotein content but the main inhibitory or stimulatory effects were focussed on the energy-rich compounds (soluble organic phosphorus) including coenzymes.

It is worth mentioning that Jouany et al. (1982) reported that toxicity of chromium ions to Chlorella vulgaris appeared in the reduction of ATP content which he considered as an early indication of growth inhibition. Petrilli and deFlora (1977) reported that hexavalent chromium directly interacted with bacterial DNA causing both frame shift mutations and base pair substitutions. Levis et al. (1978) proved that hexavalent chromium stimulated whereas trivalent chromium inhibited nucleoside uptake. DNA synthesis was inhibited by both types; more prominently by dichromate ions.

Balakrishnan and Villafranca (1978) proved that Cr^{3+} is a competitive inhibitor for manganese and magnesium in the biological reactions involving ATP and ADP. Kluger and Smith (1978) showed that Cr^{3+} could combine with thiamine pyrophosphate, thus inhibiting TPP-requiring enzymes including pyruvate decarboxylase. Donenberg and Gleland (1975) and Gupta et al. (1976) revealed the fact that chromium binds with ATP and thus interfered with hexokinase and pyruvic kinase; Cr-ADP-hexose-6-phosphate being very slowly released whereas Cr-ATP increased the rate of enolization of pyruvic acid.

The results of this investigation further show that previous spraying or administration of chromium salts through the soil reduced the alkaloid content per unit dry weight of leaves; a phenomenon that was furthered with concentration and/or repeated treatment. Under all conditions, soil application was less deleterious than previous spraying.

Chromic ions were least effective when absorbed through roots than from leaves especially at the higher concentrations. Repeated previous spraying with either chromium ions was equally inhibitory regardless concentration except 5×10^{-5} M chromic that exerted slight, if at all, inhibitory effect. Similarly

repeated soil application of 5×10^{-5} M chromium ions had a mild inhibitory effect on total alkaloids but larger doses were more effective; chromic ions being least.

Apart from these effects on total alkaloids, chromium ions increased the accumulation of some individual alkaloids viz. tropine, valeroidine and meteloidine on the expense of other alkaloids. These effects may be of economic value from the pharmaceutical and/or therapeutic point of view.

In the meantime application of chromium ions to the soil, at 5×10^{-5} M, seemed to trigger fruit setting and seed formation as observed from the very large increase in fruit weight as well as weight of seeds per capsule. The insignificant effect of all chromium treatments on percentage seeds in the capsule indicates that these ions did not affect the biological mechanisms but only altered the rate of fruit formation and setting. This is further confirmed by the fact that, under most conditions, the weight of 100 seeds was insignificantly affected except for few cases viz. treatment with 5×10^{-5} M chromate.

Larger doses of chromium ions had minor effects on fruit setting and seed formation except chromic ions that stimulated fruit and seed weight thus confirming the earlier deductions that chromic ions act as an indispensible microelement, increasing the yield of grapes (Dobralyubskii and Slavvo 1957, 1958, Rusko, 1968 a,b) and Dactylis glomerata (Lobnik and Vidrih 1976 and Vidrih and Lobnik 1976),

SUMMARY

The results of this investigation clearly show the persistant inhibitory effects of previous spraying the Datura plants leaves with various concentrations of chromium salts on leaf area of the progeny but fresh weight gain was hardly affected whereas dry weight gain of the produced leaves was stimulated.

Absorption of chromate or chromic through the roots increased leaf area, fresh and dry weight gain. Dichromate limited the leaf area and fresh weight but dry weight of leaves increased. Repeated dosage of chromic ions had the same stimulatory effect whereas repeated dosage of dichromate ions was still inhibitory to leaf area with minor effects on fresh and dry weight but repeated dosage of chromate alleviated its stimulatory effects.

With progress of age, previous leaf spraying with chromate or dichromate severely attenuated chlorophyll a, chlorophyll b and carotenoid content whereas chromic ions were stimulatory. Soil application of chromium reduced pigmentation; dichromate being most and chromic being least effective. Repeated dosage with the hexavalent ion was still suppressive but the trivalent ion was stimulatory.

Previous spraying resulted in low nitrogen accumulation in the produced leaves; a phenomenon that was almost alleviated by the end of the season due to gradual decrease of nitrogen content of the control leaves. The ratio of insoluble nitrogen was greater in the treated than control leaves; a phenomenon that was reversed, with progress of age.

Soil application of chromium salts drastically inhibited nitrogen accumulation in the leaves. First treatment enhanced whereas repeated treatments suppressed insoluble nitrogen accumulations.

Previous spraying with chromate exerted minor effects whereas chromic ions lowered the total carbohydrate content of the leaves. Similarly single irrigation with chromium salts exerted minor inhibitory effects on total carbohydrates but repeated irrigation were inhibitory.

Previous leaf spraying slightly lowered total phosphorus content of the produced leaves; a phenomenon that was counteracted or even reversed with progress of age; soluble organic phosphorus largely participated in these fluctuations. Supplementation of chromium ions through the roots had almost similar effect though repeated dosage did not affect the original phosphorus content.

Both chromium treatments reduced the alkaloid content of the leaves; a phenomenon that was furthered with rise of concentration and/or repeated dosage. Soil application was less deleterious than previous spraying. Apart from such effect chromium ions significantly increased tropine, valeroidine and meteloidine content of the leaves.

Small doses of chromium, applied via the soil, triggered fruit setting and seed formation. Larger doses had minor effects except chromic ions that stimulated fruit and seed weight.

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بسم الله الرحمن الرحيم

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ملخص رسالة دكتوراه الفلسفة للسيده/ منى محمد الحسينى عليوه

بعنوان: " دراسات تكميلية على التأثيرات الأيضية لأملاح الكروم

فى نبات الداتوره "

أوضحت نتائج هذا البحث استمرارية الآثار المثبطة لعمليات رش أوراق نبات الداتوره بالتركيزات المختلفة لاملاح الكروم على مساحة أوراق نباتات المحصول الا أن زيادة الوزن الطرى تكاد تكون معدومة فى حين ازداد معدل تراكم الوزن الجاف بشكل واضح.

ولكن امتصاص الكروم أو الكروميك عن طريق الجذور ساعد على زيادة مساحة الأوراق ووزنها الطرى والجاف بينما ايون ثنائى الكروم حفز زيادة الوزن الجاف مع نقص فى مساحة الأوراق ووزنها الطرى .

وقد تبين ان الجرعات المتكررة من ايون الكروميك لا تزال تعطى نفس التأثير المنشط بينما الجرعات المتكررة من ايون ثنائى الكروم لا يزال مثبطا لمساحة الأوراق دون تأثير ملحوظ على الوزن الطرى والجاف اما تكرار جرعات الكروم فانها تعادل التأثير النشط لهذا الايون.

وقد تبين ان سابق الرش بايون الكروم أوثنائى الكروم قد أنقص بوضوح الكروفيل أ ، ب والكاروتينات فى اوراق نباتات المحصول خاصة مع التقدم فى عمر النباتات بينما نفس المعاملة بايونات الكروميك كانت منشطة ولكن معاملة النباتات بالكروم ، من خلال التربة، كان مثبطا لمحتوى الصبغيات خاصة ثنائى الكروم بينما ايون الكروميك كان أقلها تأثيرا وقد لوحظ تكرار جرعات ايون الكروم السداسى لا يزال مثبطا ولكن تكرار جرعات الايون الثلاثى كانت منشطة لهذه العمليات.

عمليات الرش السابقة انقصت من تراكم النيتروجين فى الاوراق الا أن زيادة عمر النبات قد عادل هذا التأثير نتيجة لنقص المحتوى النيتروجينى للاوراق الغير معاملة مع ملاحظة زيادة نسبة النيتروجين الغير ذائب فى الأوراق المعاملة عنها فى الغير معاملة خلال الفترات الأولى من نمو النبات والتى انعكست بتقدم العمر وقد انخفضت بشدة كمية النيتروجين المتراكم فى اوراق النباتات التى اعطيت املاح الكروم عن طريق التربة مع الاخذ فى الاعتبار ان المعاملة الأولى حفزت والمعاملات المتكررة ثبطت من تراكم النيتروجين الغير ذائب .

سابق تكرار الرش بالكرومات لم يوءثر تقريبا على المحتوى الكربوهيدراتى بينما ايونات الكروميك قد انقص محتوى الكربوهيدرات الكلى للاوراق كذلك فان الرى مرة واحدة باملاح الكروم لم يقلل معنويا من المحتوى الكربوهيدراتى الكلى ولكن تكرار الرى كان مثبطا وقد أدى سابق الرش الى نقص طفيف فى المحتوى الفوسفورى الكلى للاوراق الناتجة الا ان تقدم عمر النباتات قد عادل او عكس هذه الظاهرة والتى شارك فى ظهورها بوضوح الفوسفور العضوى الذائب . كذلك فان تغذية نباتات الداتورة بايونات الكروم عن طريق الجذور له نفس التأثير على محتوى الفوسفور للاوراق الا ان تكرار المعاملة لا يوءثر على المحتوى الاساسى. لوحظ ايضا ان الكروم (بغض النظر عن طريقة وصوله للنبات) يقلل من محتوى القلويدات للاوراق ويزداد هذا التأثير وضوحا بزيادة تركيز الايون الا ان امتصاص الكروم عن طريق الجذور اقل ضررا من امتصاصه عن طريق الأوراق ويرغم هذا التأثير المثبط فان كمية التروبين والفاليرويدين والمتيلويدين قد زادت فى الاوراق كما تبين ان امتصاص الكروم عن طريق الجذور ينشط عقد الثمار وتكوين البذور الا التركيزات العالية اقل أثرا فيما عدا ايونات الكروميك التى تزيد من وزن الثمار والبذور.

دراسات تكميلية
على التأثيرات الأيضية لأملاح الكروم
في نبات الداتورة

رسالة مقدمة إلى
كلية العلوم - جامعة القاهرة

للحصول على
دكتوراه الفلسفة في العلوم "نبات"
فسيولوجيا

مقدمة من
متى محمد الحسيني إبراهيم عليوه
بكالوريوس علوم - جامعة القاهرة ١٩٧٥
ماجستير في العلوم - جامعة القاهرة ١٩٧٩

جامعة القاهرة - كلية العلوم - قسم النبات
سبتمبر ١٩٨٣