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DESCRIPTION

TECHNICAL FIELD

[0001] The present invention relates to foliar application of an aqueous composition to mitigate phytotoxicity in plants that is caused by exposure of the plants to phytotoxic levels of sodium chloride.

BACKGROUND

[0002] Various mixtures of organic compounds have been proposed in the art as fertilizer additives. Specifically, a humic acid composition, Bio-Liquid Complex™, is stated by Bio Ag Technologies International (1999) www.phelpstek.com/portfolio/humic_acid.pdf to assist in transferring micronutrients, more specifically cationic nutrients, from soil to plant.

[0003] TriFlex™ Bloom Formula nutrient composition of American Agritech is described as containing "phosphoric acid, potassium phosphate, magnesium sulfate, potassium sulfate, potassium silicate[and] sodium silicate." TriFlex™ Grow Formula 2-4-1 nutrient composition of American Agritech is described as containing "potassium nitrate, magnesium nitrate, ammonium nitrate, potassium phosphate, potassium sulfate, magnesium sulfate, potassium silicate, and sodium silicate." Both compositions are said to be "fortified with selected vitamins, botanical tissue culture ingredients, essential amino acids, seaweed, humic acid, fulvic acid and carbohydrates." See, e.g., www.horticulturesource.com/product_info.php/products_id/82. These products are said to be formulated primarily for "soilless hydrogardening" (i.e., hydroponic cultivation) of fruit and flower crops, but are also said to outperform conventional chemical fertilizers in container soil gardens. Their suitability or otherwise for foliar application as opposed to application to the hydroponic or soil growing medium is not mentioned. See www.americanagritech.com/product/product detail.asp?ID=l&pro id pk=4-0.

[0004] The trademark Monarch™, owned by Actagro, LLC is a fertilizer composition containing 2-20-15 primary plant nutrients with 3% non plant food organic compositions derived from natural organic materials.

[0005] Plants in general are susceptible to a variety of environmental stresses, including for example, drought, salinity, low light, water logging, disease, pests, and temperature. Conventional nutritional plant treatments are generally unable or incapable of effecting plant biology under such conditions.

SUMMARY

[0006] The present invention provides the use of foliar application of an aqueous composition to mitigate phytotoxicity in plants that is caused by exposure of the plants to phytotoxic levels of sodium chloride, as defined in claim 1. As set out in that claim, the aqueous composition is characterized by comprising an aqueous mixture of complex polymeric polyhydroxy acids having a predetermined amount of total organic carbon (TOC), and the complex polymeric polyhydroxy acids are derived from partially humified organic matter. The complex polymeric polyhydroxy acids are further characterised by all of the parameters a-d: a. the complex polymeric polyhydroxy acids comprise a mixture of condensed aromatic hydrocarbons, lignins, and tannins and/or condensed tannins; b. the complex polymeric polyhydroxy acids have an oxygen-to-carbon ratio that is greater than 0.5 for dissolved organic matter (DOM) present in the aqueous mixture; c. the complex polymeric polyhydroxy acids comprise a total number of tannin compounds greater than 200, the tannin compounds having a hydrogen to carbon ratio of 0.5 to 1.4, and an aromaticity index of less than 0.7 as measured by mass spectroscopy; d. the complex polymeric polyhydroxy acids comprise a mass distribution of 55-60% lignin compounds, 27-35% tannin compounds; and 8-15% condensed aromatic hydrocarbon as measured by mass spectroscopy.

BRIEF DESCRIPTION OF THE FIGURES

[0007]

FIG. 1A. Graphical representation of plant vigor versus control after treatment with embodiments of the present disclosure;

FIG. 1B Graphical representation of leaves per plant versus control after treatment with embodiments of the present disclosure;

FIG. 2. Graphical representation of average plant height versus control after treatment with embodiments of the present disclosure;

FIG. 3. Graphical representation of plant weight versus control after treatment with embodiments of the present disclosure;

FIG. 4. Graphical representation of plant root weight versus control after treatment with embodiments of the present disclosure;

FIG. 5. Graphical representation of plant shoot weight versus control after treatment with embodiments of the present disclosure;

FIG. 6. Graphical representation of plant leaf conductance versus control after treatment with embodiments of the present disclosure;

FIG. 7. Graphical representation of plant vigor, leaf number, plant height, plant weight, plant root weight, and plant shoot weight versus control after treatment with embodiments of the present disclosure;

FIG. 8. Graphical representation of plant vigor, leaf number, plant height, plant weight, plant root weight, and plant shoot weight versus control after treatment with embodiments of the present disclosure;

FIG. 9. Graphical representation of plant weight, plant root weight, and plant shoot weight versus control after treatment with embodiments of the present disclosure; and

FIG. 10 Graphical representation of plant weight, plant root weight, and plant shoot weight versus control after treatment with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0008] Greenhouse and field experiments have demonstrated that CPPA (where CPPA is CAS Reg. No.1175006-56-0, which is an alkaline extract of Complex Polymeric Polyhydroxy Acids) from organic matter, can promote plant growth and development so as to increase crop yields. Physiological studies indicate that CPPA provides improved nutrient availability and mobility inside the plants. Additionally, CPPA augments synthesis or availability of plant hormones, and/or CPPA possesses synergetic actions with some of these plant hormones. At the molecular level, plant growth and development activities are controlled and/or influenced by genes and gene expression, processes that are affected by contact with CPPA. It is likely that CPPA acts through triggering or altering the expression of critical genes involved in plant growth, development, stress tolerance, and/or disease resistance.

[0009] The phrase "foliar surface" herein is inclusive of a leaf surface and other green parts of plants having surfaces that may permit absorption of active ingredient, including petioles, stipules, stems, bracts, flowerbuds, etc., and for present purposes "foliar surfaces" will be understood to include surfaces of such green parts.

[0010] The compositions of matter disclosed herein but not claimed comprise a mixture of organic molecules isolated and extracted from sources rich in natural organic matter into an aqueous solution. The natural organic matter is primarily derived from plant materials that have been modified to varying degrees over time in a soil environment. Some of the plant materials have been recently deposited in the environment. At least a part of the natural organic matter has passed through a partial process of humification to become partially humified natural organic matter. Humification includes microbial, fungal, and/or environmental (heat, pressure, sunlight, lightning, fire, etc.) degradation and/or oxidation of natural organic matter. The composition of matter contains natural organic matter that has not substantially undergone humification (partially humified natural organic matter).

[0011] Natural organic matter is extremely complex, with thousands of compounds generally present, depending upon the source and the environmental conditions prevalent about the source. The composition of matter disclosed herein but not claimed contains dissolved organic matter, the organic matter being formed during the process of humification as described above, such as microbial, fungicidal, and/or environmental (heat, pressure, sunlight, lightning, fire, etc.) degradation processes. The amount of humification can be determined and characterized using known methods, for example, by 13C NMR, using controls of fully or completely humified natural organic matter, such as humic substances standards from the International Humic Substances Society, for example, Leonardite Humic Acid (LHA), Pahokee Peat Humic Acid (PPHA), and Suwannee River Fulvic Acid II (SRFA).

[0012] CPPA, which is described but not claimed, can be obtained by removing a natural organic matter from its source, optionally processing, and/or concentrating to provide a CPPA composition having a dissolved organic matter (DOM) concentration level of about 10X, 25X, 50X, 100X, 200X, 300X, 400X, 500X, 600X, 700X, 800X, 900X, 1000X, 1500X, 2000X, 2500X, 3000X, 3500X, 4000X, 4500X, or 5000X (where X is "times") relative to its original source. CPPA concentrations of dissolved organic matter (DOM) concentration level can be about 7500X, 10,000X, 15,000X, 20,000X, 25,000X, and up to 50,000X. CPPA compositions may be adjusted such that the concentration of DOM is between about 10 ppm to about 700,000 ppm. CPPA may be adjusted such that the concentration of DOM is between about 1000 ppm to about 500,000 ppm. CPPA compositions may be adjusted to a DOM value represented by any ppm value between 1000 ppm and 50,000 ppm, inclusive of any ppm value in 500 ppm increments (e.g., 10,500 ppm, 11,000 ppm, 11,500 ppm, 12,000 ppm, etc.) in aqueous solution.

[0013] CPPA contains a complex mixture of substances, typically a heterogeneous mixture of compounds for which no single structural formula will suffice. Detailed chemical and biological testing has shown that CPPA is a unique composition both in its biological effect on plants and its chemical composition compared to Humic and Fulvic acids. Elemental and spectroscopic characterization of CPPA (and CPPA) material differentiates it from most other humic-based organic complexes, such as Humic and Fulvic Acids, as further discussed below. Blending of CPPA compositions may be performed to provide consistency of material and to compensate for the normal variations of a naturally-derived material.

[0014] Humic substances such as Fulvic Acid (CAS Reg. No. 479-66-3) and Humic Acid (CAS Reg. No. 1415-93-6) are contrasting examples of organic complexes that are derived from natural organic matter, but, as detailed below, CPPA is chemically and biologically unique from Fulvic and Humic acid. Humic substances such as Fulvic Acid and Humic Acid generally do not contain appreciable amounts of metal ions, either naturally or from processing.

Characterization Methods

[0015] The organic compounds making up CPPA can be characterized in a variety of ways (e.g., by molecular weight, distribution of carbon among different functional groups, relative elemental composition, amino acid content, carbohydrate content, etc.).

[0016] For purposes of characterizing carbon distribution among different functional groups, suitable techniques include, without limitation, 13C-NMR, elemental analysis, Fourier transform ion cyclotron resonance mass spectroscopy (FTICR-MS) and Fourier transform infrared spectroscopy (FTIR). The chemical characterization of CPPA and Humic substance standards were carried out using Electro spray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectroscopy (ESI-FTICR-MS), Fourier Transform Infrared Spectroscopy (FTIR) and elemental analysis for metals using ICP-AES, conducted by Huffman Laboratories, Inc. and the University of Washington.

[0017] Elemental, molecular weight, and spectroscopic characterization of CPPA is consistent with an organic complex that consists primarily of lignin and tannin compounds (and mixtures of condensed and un-condensed tannin), condensed aromatics and trace amounts of lipid and inorganics. Thousands of compounds are present, with molecular weights ranging from 225 to 700 daltons, the majority of compounds having between about 10 to about 39 carbon atoms per molecule. CPPA compositions are generally composed of carbon, oxygen, and hydrogen, with small amounts of nitrogen, and sulfur.

[0018] The elemental composition of the dissolved solids typically present in CPPA compositions is given in Table A. If the organic compounds are separated from the inorganic compounds, the elemental breakdown is: C 55%, H 4%, 0 38%, N 1.8%, and S 2.2%.

Table A. Average Elemental Composition of dissolved solids, based upon average values from 10 different CPPA lots (without removal of inorganic compounds).

Element	%
Carbon	35.1
Oxygen	24.6
Hydrogen	2.5
Sulfur	2.1
Nitrogen	1.3
Potassium	27.3
Iron	6.1
Calcium	0.2
Sodium	0.2
Phosphorous	0.1
Other	0.5

[0019] Among the classes of organic compounds present in CPPA, analysis generally reveals that there are lignin and tannin (mixture of condensed and un-condensed, as these terms relate to organic ring(s) structures), condensed aromatics, unidentified substances and some lipids present. Each of these classes of compounds is further characterized by a rather narrow Mw range and number of carbons/molecule. The breakdown of the number average and percentage of each of the various compound classes, their MW's and carbon atoms/molecule (Carbon Range) for a representative sampling of CPPA (essentially with or without metal ions) is given in Table B1.

Table B1. Compound Classes in CPPA along with size and carbon ranges for compounds in each class. Based upon composite of 3 different production batches. Results for individual batches are very similar.

Compound Class	**# Compounds**	**% of Total**	**Size Range (daltons)**	**Carbon Range**
Lignin	1139	57	226 - 700	11 to 39
Tannin	587	30	226 - 700	10 to 31
Condensed Aromatic	220	11	238 - 698	13 to 37
Lipid	18	1	226 - 480	14 to 30
Carbohydrate	1	0	653	24
Other	23	1	241 - 651	12 to 33

[0020] A breakdown of the number average and percentage of each of the various compound classes, their MW's and carbon atoms/molecule (Carbon Range) for a second representative sampling based upon an average of 3 different production batches (essentially with or without metal ions) for the composition of matter is given in Table B2.

Compound Class	**#Compounds**	**% of Total**	**Size Range (daltons)**	**Carbon Range**
Lignin	711	56	226-700	11 to 39
Tannin	410	33	226-700	10 to 31
Condensed Aromatic	122	10	238- 698	13 to 37
Lipid	12	~1	226-480	14 to 30
Carbohydrate	1	0	653	24
Other	14	~1	241-651	12 to33

Table B2. Compound Classes in the composition of matter, along with size and carbon ranges for compounds in each class. Based upon average of 3 different CPPA production batches. Results for individual batches are very similar.

[0021] Table C summarizes the oxygen-to-carbon (O/C) and hydrogen-to-carbon (H/C) ratios used in defining the classes described above.

Table C. Elemental Ratios and chemical classifications used in characterizing CPPA samples.

Class	**O/C**	**H/C**	**Aromaticity Index**
Lignin	0.15-0.6	0.6 - 1.7	<0.7
Tannin	0.6-1.0	0.5 - 1.4	<0.7

Class	O/C	H/C	Aromaticity Index
Condensed Aromatic	0.1-0.7	0.3 - 0.7	>0.7
Lipid	0-0.2	1.8 - 2.2	
Carbohydrate	0.6-1.0	1.8 - 2.2	

[0022] Comparative elemental and structural characterization of Humic Substances versus CPPA was performed. Three humic substances standards from the International Humic Substances Society were used: Leonardite Humic Acid (LHA), Pahokee Peat Humic Acid (PPHA), and Suwannee River Fulvic Acid II (SRFA). Each humic substance standards and each CPPA sample was analyzed by FTIR and ESI-FTICR-MS. A portion of each humic substance standard was dissolved in water/methanol, with ammonium ions added for ionization enhancement, for the ESI-FTICR-MS analysis. Three samples of CPPA (CP#60, CPPA#75, and CPPA#99) were prepared for analysis with cation exchange resin (AG MP-50, Bio-Rad Laboratories, Hercules, CA) to remove metals that otherwise would interfere with the analysis. Comparison of the Humic Substance standards and each sample of the composition of matter are presented in Table D.

Sample	O/C	H/C	DBE	Avg. MW
Suwannee River Fulvic Acid (SRFA)	0.39	1.01	12.7	445.7
Pahokee Peat Humic Acid (PPHA)	0.34	0.75	16.29	429.8
Leonardite Humic Acid (LHA)	0.3	0.79	15.8	423.6
CPPA#60	0.54	0.87	13.7	472.9
CPPA#75	0.54	0.89	13.23	456.9
CPPA#99	0.5	0.91	13.23	455.7

Table D. Comparison of humic substance standards and each CPPA sample.

[0023] Table D indicates that there are major differences between the Humic Substances standards and the CPPA samples. For example, the O/C ratio is less than 0.4 in all of the Humic Substances but is over 0.5 for the CPPA samples. The DBE for the CPPA samples is also significantly lower than for the Humic Acid Standards and the average MW is greater.

[0024] Based on mass spectral analysis, there are a number of compounds present in the CPPA samples that are substantially absent or greatly reduced in the Humic Substance standards. In particular, at least one component of CPPA may correspond with one or more tannin compounds. By comparison, in the Humic Substance standards, %tannin compounds are present in a small amount. For example, in the Fulvic Acid standard and in the Humic Acid standards, both standards are at least 3X-4X less than the % tannins found in the CPPA samples, as shown in Table E.

Sample	# tannins	% of tannin compounds
Suwannee River Fulvic Acid (SRFA)	192	8.8
Pahokee Peat Humic Acid (PPHA)	9	1.2
Leonardite Humic Acid (LHA)	22	1.2
CPPA#60	441	35.2
CPPA#75	357	34.6
CPPA#99	432	28.3

Table E. Number and % tannins in Humic Substance Standards verses CPPA.

[0025] Comparing the Fourier Transform Infrared (FTIR) spectra for the IHSS standards and CPPA samples, there are similarities, primarily in the region from 1600 to 1800 cm^{-1}. In both sets of samples we see a very strong peak at around 1700 cm^{-1} due to the C=O stretch from a carbonyl functional group and a peak in the 1590 to 1630 region which is consistent with a C=C bond from alkenes or aromatics. However, significant differences in the region from 700 to 1450 cm^{-1} are observed. Peaks at 1160 to 1210 are present in all the spectra and are from the C-O bond of alcohols, ethers, esters and acids. The biggest difference is the peak at 870 cm^{-1} in the CPPA samples, which is absent in the IHSS standards. This peak may be due to the C-H bond of alkenes and aromatics or a methoxy group.

[0026] Based on the above chemical, elemental and structural characterization, CPPA is chemically and biologically unique from Humic and Fulvic acids or combinations thereof.

[0027] Based on the characterization data, the CPPA may contain relatively small molecules or supramolecular aggregates with a molecular weight distribution of about 300 to about 18,000 daltons or greater. Included in the organic matter from which the mixture of organic molecules are fractionated are various humic substances, organic acids and microbial exudates. The mixture is shown to have both aliphatic and aromatic characteristics. Illustratively, the carbon distribution shows about 30-35% in carbonyl and carboxyl groups; about 30% in aromatic groups; about 18-22% in aliphatic groups, about 7% in acetal groups; and about 12% in other heteroaliphatic groups.

[0028] In some embodiments, the mixture of compounds in the CPPA comprises organic molecules or supramolecular aggregates with a molecular weight distribution of about 200 to about 30,000 daltons, for example, about 200 to about 25,000 daltons, about 200 to about 20,000 daltons, or about 200 to about 18,000 daltons.

[0029] Among classes of organic compounds that can be present in the CPPA are amino acids, carbohydrates (monosaccharides, disaccharides and polysaccharides), sugar alcohols, carbonyl compounds, polyamines, lipids, and mixtures thereof. These specific compounds typically are present in minor amounts, for example, less than 5% of the total % of compounds.

Examples of amino acids that can be present include without limitation arginine, aspartic acid, glutamic acid, glycine, histidine, isoleucine, serine, threonine, tyrosine and valine. Examples of monosaccharide and disaccharide sugars that can be present include without limitation glucose, galactose, mannose, fructose, arabinose, ribose and xylose.

[0030] A suitable mixture of organic compounds can be found, for example, as one of many components in products marketed as CARBON BOOST™-S soil solution and KAFETM-F foliar solution of Floratine Biosciences, Inc. (FBS). Information on these products is available at www.fbsciences.com.

[0031] Vegetable crops include without limitation:

leafy and salad vegetables such as amaranth, beet greens, bitterleaf, bok choy, Brussels sprout, cabbage, catsear, celtuce, choukwee, Ceylon spinach, chicory, Chinese mallow, chrysanthemum leaf, corn salad, cress, dandelion, endive, epazote, fat hen, fiddlehead,

fluted pumpkin, golden samphire, Good King Henry, ice plant, jambu, kai-lan, kale, komatsuna, kuka, Lagos bologi, land cress, lettuce, lizard's tail, melokhia, mizuna greens, mustard, Chinese cabbage, New Zealand spinach, orache, pea leaf, polk, radicchio, rocket (arugula), samphire, sea beet, seakale, Sierra Leone bologi, soko, sorrel, spinach, summer purslane, Swiss chard, tatsoi, turnip greens, watercress, water spinach, winter purslane and you choy;

flowering and fruiting vegetables such as acorn squash, Armenian cucumber, avocado, bell pepper, bitter melon, butternut squash, caigua, Cape gooseberry, cayenne pepper, chayote, chili pepper, cucumber, eggplant (aubergine), globe artichoke, luffa, Malabar gourd, parwal, pattypan squash, perennial cucumber, pumpkin, snake gourd, squash (marrow), sweetcorn, sweet pepper, tinda, tomato, tomatillo, winter melon, West Indian gherkin and zucchini (courgette);

podded vegetables (legumes) such as American groundnut, azuki bean, black bean, black-eyed pea, chickpea (garbanzo bean), drumstick, dolichos bean, fava bean (broad bean), French bean, guar, haricot bean, horse gram, Indian pea, kidney bean, lentil, lima bean, moth bean, mung bean, navy bean, okra, pea, peanut (groundnut), pigeon pea, pinto bean, rice bean, runner bean, soybean, tarwi, tepary bean, urad bean, velvet bean, winged bean and yardlong bean;

bulb and stem vegetables such as asparagus, cardoon, celeriac, celery, elephant garlic, fennel, garlic, kohlrabi, kurrat, leek, lotus root, nopal, onion, Prussian asparagus, shallot, Welsh onion and wild leek;

root and tuber vegetables, such as ahipa, arracacha, bamboo shoot, beetroot, black cumin, burdock, broadleaf arrowhead, camas, canna, carrot, cassava, Chinese artichoke, daikon, earthnut pea, elephant-foot yam, ensete, ginger, gobo, Hamburg parsley, horseradish, Jerusalem artichoke, jicama, parsnip, pignut, plectranthus, potato, prairie turnip, radish, rutabaga (swede), salsify, scorzonera, skirret, sweet potato, taro, ti, tigernut, turnip, ulluco, wasabi, water chestnut, yacon and yam; and herbs, such as angelica, anise, basil, bergamot, caraway, cardamom, chamomile, chives, cilantro, coriander, dill, fennel, ginseng, jasmine, lavender, lemon balm, lemon basil, lemongrass, marjoram, mint, oregano, parsley, poppy, saffron, sage, star anise, tarragon, thyme, turmeric and vanilla.

[0032] Fruit crops include without limitation: apple, apricot, banana, blackberry, blackcurrant, blueberry, boysenberry, cantaloupe, cherry, citron, clementine, cranberry, damson, dragonfruit, fig, grape, grapefruit, greengage, gooseberry, guava, honeydew, jackfruit, key lime, kiwifruit, kumquat, lemon, lime, loganberry, longan, loquat, mandarin, mango, mangosteen, melon, muskmelon, orange, papaya, peach, pear, persimmon, pineapple, plantain, plum, pomelo, prickly pear, quince, raspberry, redcurrant, starfruit, strawberry, tangelo, tangerine, tayberry, ugli fruit and watermelon.

[0033] Seed crops include without limitation: specialized crops used to produce seed of any plant species, including cereals (e.g., barley, corn (maize), millet, oats, rice, rye, sorghum (milo) and wheat), non-gramineous seed crops such as buckwheat, cotton, flaxseed (linseed), mustard, poppy, rapeseed (including canola), safflower, sesame and sunflower.

[0034] Other crops, not fitting any of the above categories, include without limitation sugar beet, sugar cane, hops and tobacco.

[0035] Compositions described herein but not claimed can be applied using any conventional system for applying liquid to a foliar surface. Most commonly, application by spraying will be found most convenient. For spraying, any conventional atomization method can be used to generate spray droplets, including hydraulic nozzles and rotating disk atomizers. Introduction of the composition into an irrigation system can be used.

[0036] For foliage surface applications, the application rate of the composition that is described but not claimed can be between about 0.001 gram/ha to about 100.0 gram/ha dry weight, between about 0.2 gram/ha to about 2.0 gram/ha dry weight, between 0.3 gram/ha to about 1.5 gram/ha dry weight, or between about 0.4 gram/ha to about 1.0 gram/ha dry weight applied as a foliar application to the foliage of the plant.

Experimental

Alkali (Earth) Metal Salt in Combination with CPPA

[0037] The purpose of these experiments were to: (1) determine if a foliar application to of CPPA in combination with phytotoxic levels of alkali (earth) salts would mitigate the phytotoxicity in plants, and if (2) there was a synergistic effect between the CPPA and alkali (earth) salts in positively effecting biological activity of plants.

[0038] ***Experiment Salt-1***: CPPA/NaCl Composition - Foliar Application - For this experiment, tomato plants (*Lycopersicon es.*) were produced from seed and transplanted into 3 inch by 3 inch pots. There were a total of 5 treatments plus an untreated check, each with 10 replicates per treatment arranged in a randomized block design. Aqueous solutions of CPPA (1000 mg TOC/L) and NaCl (5000 mg/L, hereinafter "salt") were used for this experiment and all plants were treated with a foliar application at the time they were transplanted into the pots. Each treatment comprised samples treated with CPPA alone, salt alone, or CPPA plus salt. Two rates of CPPA were used; the first was equivalent to 520 mg of TOC per hectare and a second equivalent to 1040 mg of TOC per hectare. Salt was applied at a rate equivalent to 2.6 g of salt per hectare. All treatments were diluted with water to provide a final spray volume equivalent to 208 lit per hectare, made with a spray bottle, with just enough spray solution to wet the leaf surface of each plant. Treatments for Experiment Salt-1 are summarized in Table 1.

Table 1 Treatments, compositions, application rate for Experiment Salt-1

Treatment		Rate (mg/ha)
1	UTC	
2	CPPA (1000 mg/L TOC)	520
3	CPPA (1000 mg/L TOC)	1040
4	NaCl (5000 mg/L)	2600
5	CPPA (1000 mg/L TOC)	520
	NaCl (5000 mg/L)	2600
6	CPPA (1000 mg/L TOC)	1040
	NaCl (5000 mg/L)	2600

[0039] Ten days after treatment the plants were assessed for vigor, leaf number, plant height, plant weight, root weight, shoot weight, and leaf conductance using a SPAD meter and are summarized in Table 2 and depicted in FIGs. 1-6.

Table 2 Summarized biological effects of compositions of CPPA/salt on tomato plant at 1000 mg/ha CPPA and 0 mg or 5000 mg/ha salt at application rates of 520 mg/ha, 1040 mg/ha, and 2600 mg/ha.

	Rate (mg/ha)	**Vigo r**	**Leaf #**	**Plt. Ht.**	**Plt. Wt.**	**Root Wt.**	**Shoo tWt.**	**SPAD**
UTC		2.9 b	6.1bcd	3.4 b	4.0 b	1.4 ab	2.7 b	31 ab
CPPA (1000 mg/L TOC)	520	3.4 a	6.4 abc	4.3 ab	4.0 b	1.1 ab	2.9 b	33.1 ab
CPPA (1000 mg/L TOC)	1040	3.6 a	6.5 abc	4.4 ab	3.9 b	1.1 ab	2.8 b	34.5 ab

	Rate (mg/ha)	Vigo r	Leaf #	Plt. Ht.	Plt. Wt.	Root Wt.	ShoottWt.	SPAD
NaCl (5000 mg/L)	2600	2.4 b	5.3 e	3.5 b	2.7 c	0.8jc	2.0 c	24.2 b
CPPA (1000 mg/L	520	3.8 a	6.6ab	4.7 a	4.0 b	1.7 a	2.9 b	35.5 a
TOC) NaCl (5000 mg/L)	2600							
CPPA (1000 mg/L TOC) NaCl (5000 mg/L)	1040	4.0 a	7.1 a	5.0 a	5.8 a	1.7 a	4.2 a	38.5 a
	2600							

[0040] These results observed and summarized in Table 2 were very consistent, where, in all but one case, the salt treatment alone gave the expected poorest results, indicating a significant amount of phytotoxicity, whereas surprisingly and unexpectedly, in every case where the salt was used in combination with CPPA, complete mitigation of the toxic effects of the salt were observed. Also, in every case, the NaCl plus CPPA treatment, effects of biological activity was observed as good or better than CPPA alone, indicating a significant synergistic effect. For total plant weight and shoot weight, the differences between CPPA alone and the CPPA plus NaCl were statistically significant at $P<0.01$.

[0041] ***Experiment Salt-2:*** Foliar Treatment of CPPA/salt formulations. The purpose of this experiment was to: (1) determine if a foliar application of low/high application rates of CPPA in combination with phytotoxic levels of salt would mitigate the phytotoxicity of salt exposure in plants, and if (2) there was a synergistic effect between low/high application rates of CPPA and varying salt rate in positively effecting biological activity of plants.

[0042] For this experiment, tomato plants (*Lycopersicon es.*) were produced from seed and transplanted into 3 inch by 3 inch pots. There were a total of 8 treatments plus an untreated check, with 20 replicates per treatment arranged in a randomized block design. Aqueous solutions of CPPA (1000 mg TOC/L) and salt (5000 mg/L) were used for this experiment and all plants were treated with a foliar application at the time they were transplanted into the pots. Each treatment contained CPPA alone, salt alone, or CPPA plus salt. Two rates of CPPA were used; the first was equivalent to 260 mg of TOC per hectare and a second equivalent to 1040 mg of TOC per hectare. The NaCl was applied at two rates, equivalent to 1.3 and 2.6 g of NaCl per hectare. All treatments were diluted with water to provide a final spray volume equivalent to 208 lit per hectare, applied with a spray bottle, with just enough spray solution to wet the leaf surface of each plant. Treatments are summarized in Table 3.

Table 3 Summary of Treatments for Experiment Salt-2.

TRT.	Formulation	Rate (mg/ha)
1	UTC	
2	CPPA (1000 mg/L TOC)	260
3	CPPA (1000 mg/L TOC)	1040
4	NaCl (5000 mg/L)	1300
5	NaCl (5000 mg/L)	2600
6	CPPA (1000 mg/L TOC)	260
	NaCl (5000 mg/L)	1300
7	CPPA (1000 mg/L TOC)	260
	NaCl (5000 mg/L)	2600
8	CPPA (1000 mg/L TOC)	1040
	NaCl (5000 mg/L)	1300
9	CPPA (1000 mg/L TOC)	1040
	NaCl (5000 mg/L)	2600

[0043] Ten days after applications, ten each of the plant samples in each treatment were assessed for vigor, leaf number, plant height, plant weight, root weight, and shoot weight. Assessments were repeated at twenty days with the remaining ten plants of each treatment and the results were averaged. FIG. 7 depicts observed vigor, leaf number, plant height, plant weight, root weight, and shoot weight results for treatments to the tomato plants with 0 mg and 260 mg CPPA/ha application rate with variable salt application rates.

[0044] FIG. 8 depicts observed vigor, leaf number, plant height, plant weight, root weight, and shoot weight results for treatments to the tomato plants with 1040 mg CPPA/ha, which is also summarized in Table 4.

Table 4 Summarized biological effects of compositions of CPPA/salt on tomato plant with 0mg CPPA/ha and 1040 mg CPPA/ha, with 1300 mg/salt and 2600 mg/salt

Treatment	Rate (mg/ha)	Vigor (1-5)	Leaf #	Plt. Ht. (inches)	Plt. Wt. (grams)	Root Wt. (grams)	Shoot Wt. (grams)
UTC		2.8 ef	4.9 cd	4.9 c	6.1 c	2.3 b	4.0 cd
CP/NaCl	1040mg/0 mg	3.1 bc	5.3 bc	5.3 ab	4.2 d	1.3 d	3.0 e
CP/NaCl	1040mg/1300 mg	2.9 cd	5.5 b	5.5 ab	7.9 a	3.3 a	4.6 a
CP/NaCl	1040mg/2600 mg	3.5 a	5.9 a	5.9 a	7.1 a	2.9 a	4.2 bc
CP/NaCl	0 mg/1300 mg	2.9 de	4.7 de	4.7 cd	3.7 d	1.4 cd	2.3 e
CP/NaCl	0 mg/2600	2.2 g	4.1 f	4.1 e	3 de	1.0 d	2.0 ef

Treatment	Rate (mg/ha)	Vigor (1-5)	Leaf #	Plt. Ht. (inches)	Plt. Wt. (grams)	Root Wt. (grams)	Shoot Wt. (grams)
	mg						

[0045] In experiment Salt-2, both rates (260 mg/ha and 1040 mg/ha) of CPPA were shown to mitigate the negative responses (phytotoxicity) caused by the exposure of salt. From the data of FIG. 7, it was observed that at the 260 mg/ha rate of CPPA, the mitigation effect was greater for the higher salt exposure rate (e.g., 2600 mg/ha salt) than for the lower rate (e.g., 1300 mg/ha salt). However at the 260 mg/ha CPPA rate, there was a substantial suppression of a synergistic effect, since in all cases, the CPPA alone prompted a larger positive response in the plants than the same rate of CPPA with either rate of salt. In FIG. 8, which depicts the higher CPPA rate of 1040 mg/ha, not only were the negative salt responses mitigated, but there was observed a synergistic effect between CPPA and the salt. The synergistic effect on plant biology was noted for both the low and high rates of salt, but this synergistic effect was slightly greater for the lower rate of salt.

[0046] ***Experiment Salt-3:*** Soil Treatments of CPPA/salt formulations - The purpose of this experiment was to determine if there is a synergistic biological effect on plants when CPPA in combination with salt was applied to soil or locus of a plant at time of planting.

[0047] For this experiment, wheat seeds *(Triticum aestivum)* were planted in small pots, approximately 1 inch in diameter and an inch in depth. There were a total of 8 treatments plus an untreated check, with 20 replicates per treatment arranged in a randomized block design. Aqueous solutions of CPPA (1000 mg TOC/L) and NaCl (5000 mg/L "salt") were used for this experiment and all pots were treated with a soil drench application immediately after the seeds were planted. All seed was planted at the same depth (~5 mm below the soil surface) and the same volume of drench solution was applied to each pot regardless of the amount of CPPA or NaCl present in that volume. Treatments contained CPPA alone, salt alone, or CPPA plus salt. Two rates of CPPA were used; the first was equivalent to 520 mg of TOC per hectare and a second equivalent to 1040 mg of TOC per hectare. The salt rates were equivalent to 1.3g and 2.6 g of NaCl per hectare. Treatments are summarized in Table 5.

Table 5 . Summary of Experimental Treatments of Experiment Salt-3

TRT.	Formulation	Rate (mg/ha)	Salt/TOC
1	UTC		
2	CPPA (1000 mg/L TOC)	520	
3	CPPA (1000 mg/L TOC)	1040	
4	NaCl (5000 mg/L)	1300	
5	NaCl (5000 mg/L)	2600	
6	CPPA (1000 mg/L TOC) NaCl (5000 mg/L)	520	2.5
		1300	

TRT.	Formulation	Rate (mg/ha)	Salt/TOC
7	CPPA (1000 mg/L TOC) NaCl (5000 mg/L)	520	5.0
		2600	
8	CPPA (1000 mg/L TOC) NaCl (5000 mg/L)	1040	1.25
		1300	
9	CPPA (1000 mg/L TOC)	1040	2.5
	NaCl (5000 mg/L)	2600	

[0048] Twenty eight days after treatment the plants were assessed for plant weight, root weight, and shoot weight. FIG. 9 depicts plant weight, root weight, and shoot weight results for treatments with 520 mg CPPA/ha in combination with varying salt rates, which are summarized in Table 6.

Table 6 Summary of Biological Effects of Compositions applied at 520 mg /ha CPPA rate with 1300 mg/ha and 2600 mg/ha salt.

Treatment	Formulation	Rate (mg/ha)	Plt. Wt	Root Wt.	Shoot Wt.
1	UTC	0	1.7e	0.3d	1.4d
2	CP	520	2.2bc	0.5a	1.8c
3	NaCl	1300	2.1cd	0.4bc	1.8c
4	NaCl	2600	2d	0.3cd	1.7c
5	CP/NaCl	520/1300	2.2b	0.4bc	1.9b
6	CP/NaCl	520/2600	2.8a	0.5a	2.3a

[0049] FIG. 10 depicts plant weight, root weight, and shoot weight results for treatments with 1040 mg CPPA/ha in combination with varying salt rates, which are summarized in Table 7.

Table 7 Results for treatments with 1040 mg CP/hectare

Treatment	NaCl/TOC	Plt. Wt	Root Wt.	Shoot Wt.
UTC		1.7f	0.3e	1.4e
CP (1040 mg TOC/ha)		2.6c	0.5b	2.1c
NaCl (1300 mg NaCl/ha)		2.1de	0.4cd	1.8d
NaCl (2600 mg NaCl/ha)		2e	0.3de	1.7d
CP (1040 mg TOC/ha)/NaCl	1.25	3.1a	0.6a	2.5a
(1300 mg/ha)				
CP (1040 mg TOC/ha)/NaCl (2600 mg/ha)	2.5	2.8b	0.5b	2.2b

[0050] In experiment Salt-3, the soil treatment of CPPA, at either 520 mg/ha or 1040 mg/ha rate, in combination with salt yielded superior results compared to the untreated check (UTC). The combination of CPPA and salt resulted in greater plant weights than for either the CPPA or salt alone. FIG. 9 shows a synergistic biological effect for soil treatment by the combination of CPPA and salt, the synergistic effect being greater for the 520 mg/ha rate of CPPA in combination with the higher salt rate (Treatment 6 of Table 6).

[0051] FIG. 10 shows that at high rates of CPPA application, e.g., 1040 mg/ha in combination with the lower rate of salt provided the greatest biological effect for plants, in this case, wheat. Likewise, the data of FIG. 10 shows a synergistic effect even for the low rate of salt in combination with CPPA, with an additive biological effect noted at the high salt rate.

REFERENCES CITED IN THE DESCRIPTION

Non-patent literature cited in the description

- CHEMICAL ABSTRACTS, 1175006-56-0 [0008]
- CHEMICAL ABSTRACTS, 479-66-3 [0014]
- CHEMICAL ABSTRACTS, 1415-93-6 [0014]

PATENTKRAV

1. Anvendelse af bladpåføring af en vandig sammensætning for at afbøde fytotoksicitet i planter, der er forårsaget af eksponering af planterne for fytotoksiske niveauer af natriumchlorid, idet den vandige sammensætning er kendetegnet ved, at den omfatter en vandig blanding af komplekse polymere polyhydroxysyrer med en forudbestemt mængde af totalt organisk carbon (TOC),
hvor de komplekse polymere polyhydroxysyrer er afledt af delvist befugtet organisk materiale,
og hvor de komplekse polymere polyhydroxysyrer yderligere er kendetegnet ved alle parametrene a-d:

a. de komplekse polymere polyhydroxysyrer omfatter en blanding af kondenserede aromatiske carbonhydrider, ligniner og tanniner og/eller kondenserede tanniner;

b. de komplekse polymere polyhydroxysyrer har et oxygen-til-carbon-forhold, der er større end 0,5 for opløst organisk stof (DOM), som er til stede i den vandige blanding;

c. de komplekse polymere polyhydroxysyrer omfatter et samlet antal af tanninforbindelser, der er større end 200, hvor tanninforbindelserne har et hydrogen-til-carbon-forhold på 0,5 til 1,4 og et aromatisk indeks på mindre end 0,7 målt ved massespektroskopi;

d. de komplekse polymere polyhydroxysyrer omfatter en massefordeling på 55-60% ligninforbindelser, 27-35% tanninforbindelser; og 8-15% kondenseret aromatisk carbonhydrid målt ved massespektroskopi.

DRAWINGS

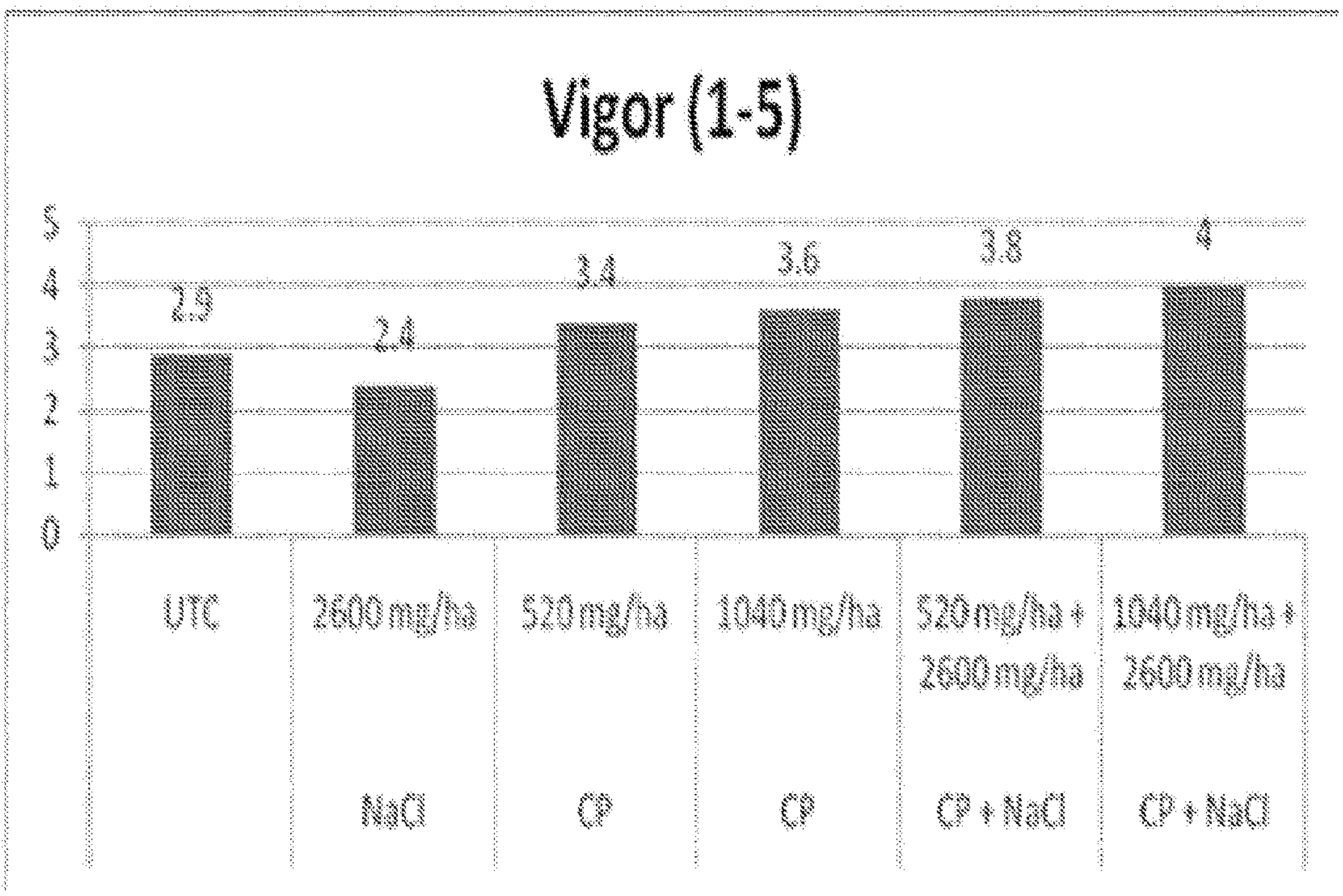

*FIG. 1*A

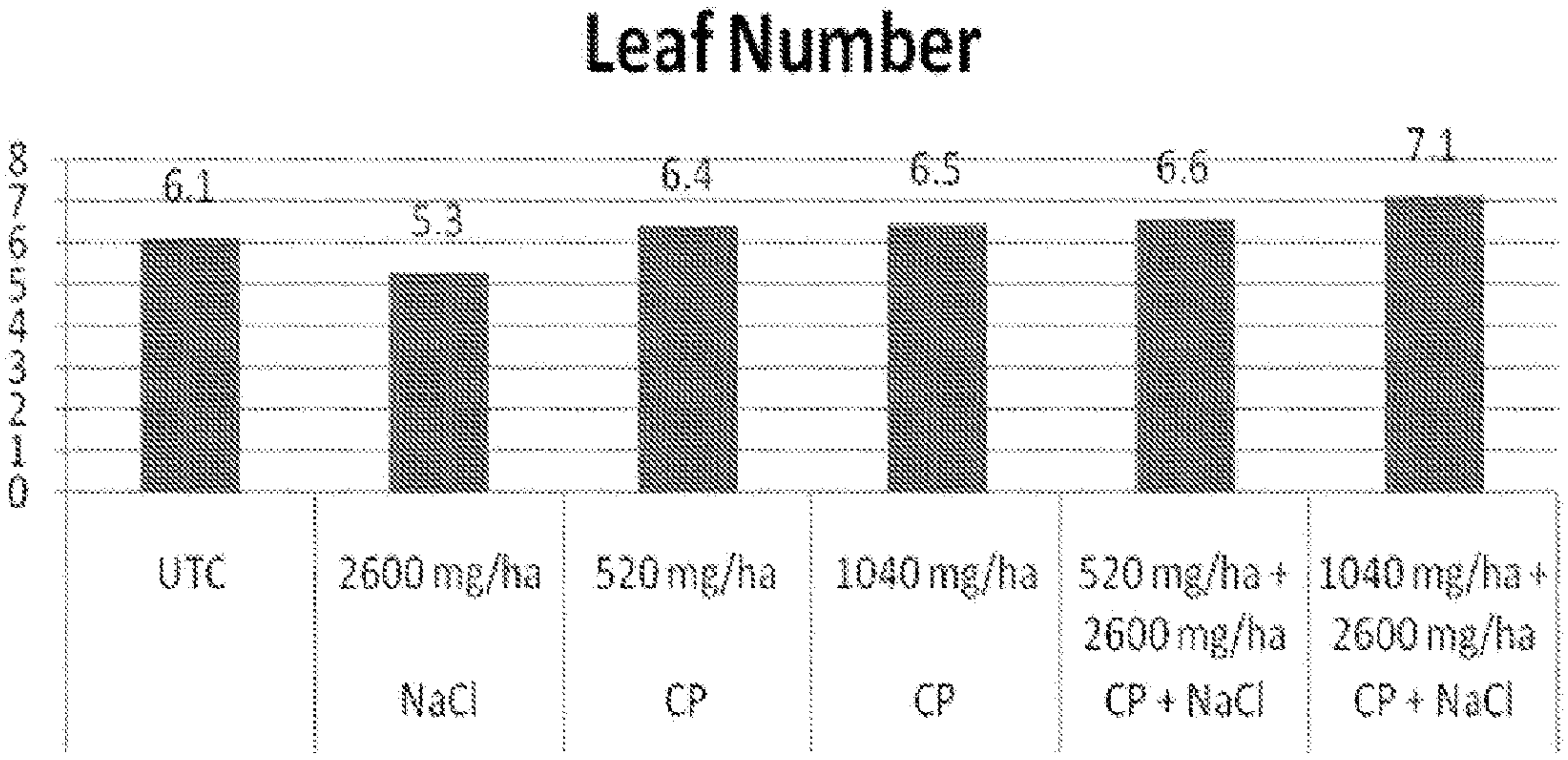

*FIG. 1*B

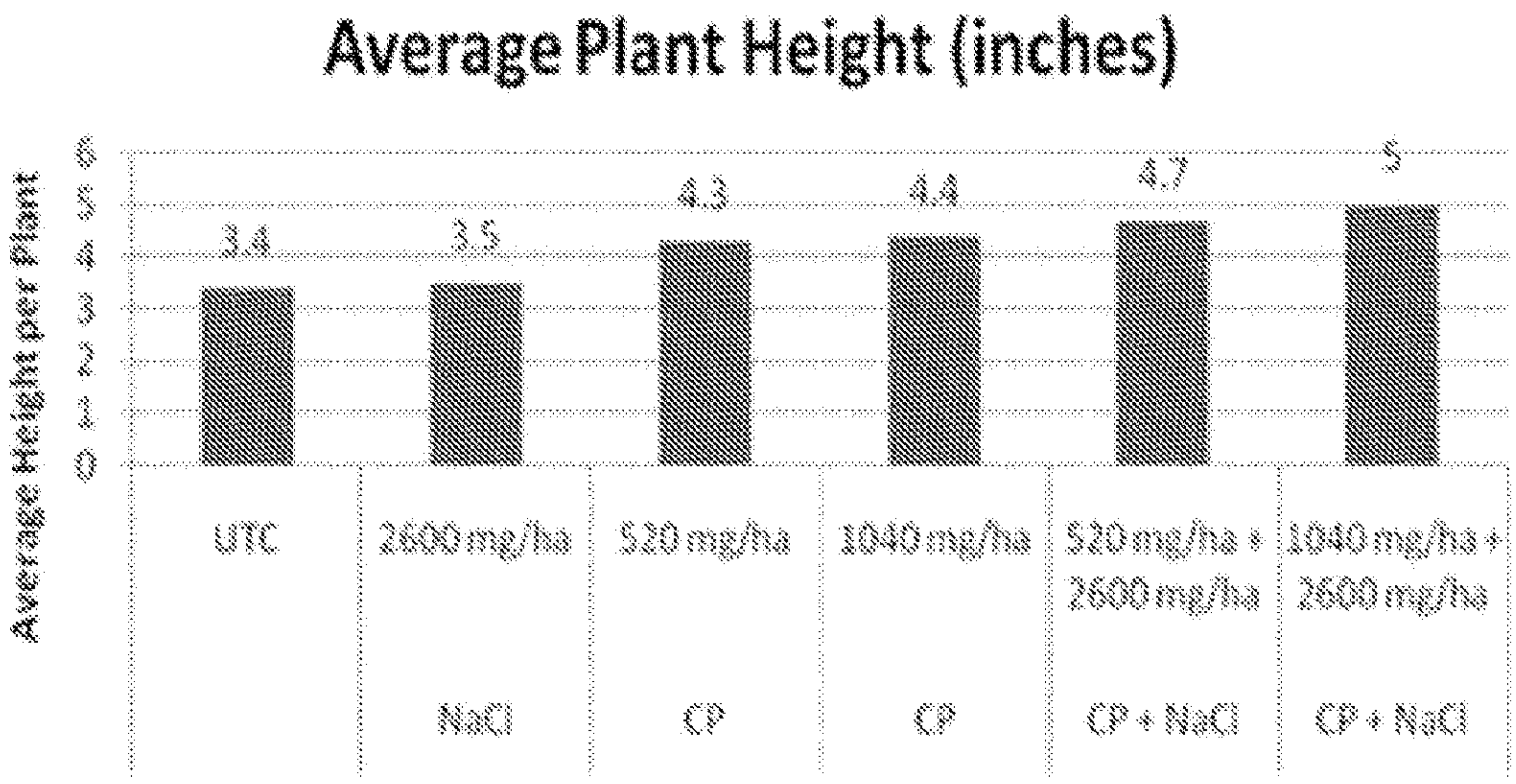
Average Plant Height (inches)
Average Height per Plant
6
5
4
3
2
1
0
3.4
3.5
4.3
4.4
4.7
5
UTC
2600 mg/ha
NaCl
520 mg/ha
CP
1040 mg/ha
CP
520 mg/ha + 2600 mg/ha
CP + NaCl
1040 mg/ha + 2600 mg/ha
CP + NaCl

FIG. 2

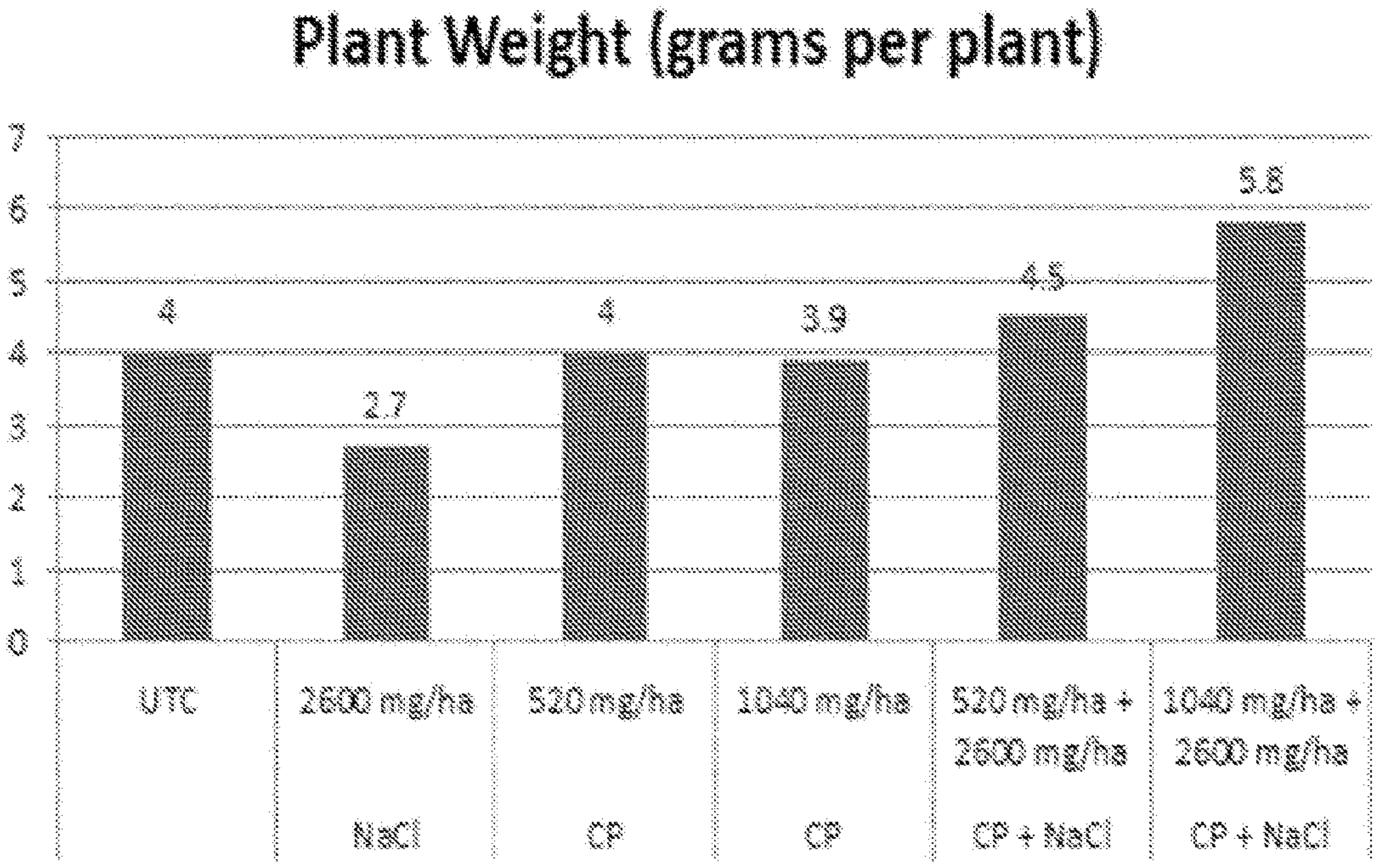
Plant Weight (grams per plant)
7
6
5
4
3
2
1
0
4
2.7
4
3.9
4.5
5.8
UTC
2600 mg/ha
NaCl
520 mg/ha
CP
1040 mg/ha
CP
520 mg/ha + 2600 mg/ha
CP + NaCl
1040 mg/ha + 2600 mg/ha
CP + NaCl

FIG. 3

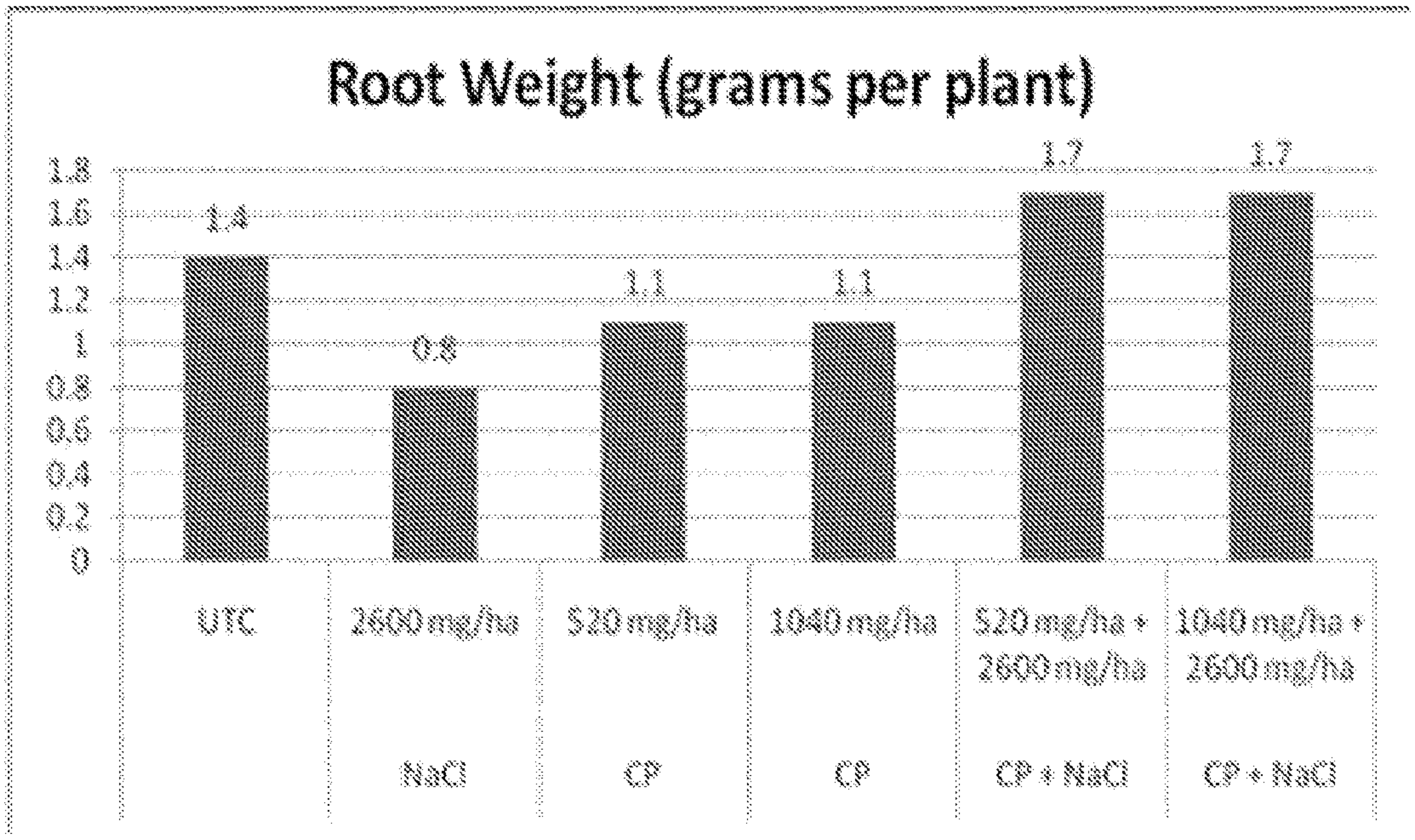
Root Weight (grams per plant)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.4
0.8
1.1
1.1
1.7
1.7
UTC
2600 mg/ha
NaCl
520 mg/ha
CP
1040 mg/ha
CP
520 mg/ha + 2600 mg/ha
CP + NaCl
1040 mg/ha + 2600 mg/ha
CP + NaCl

FIG. 4

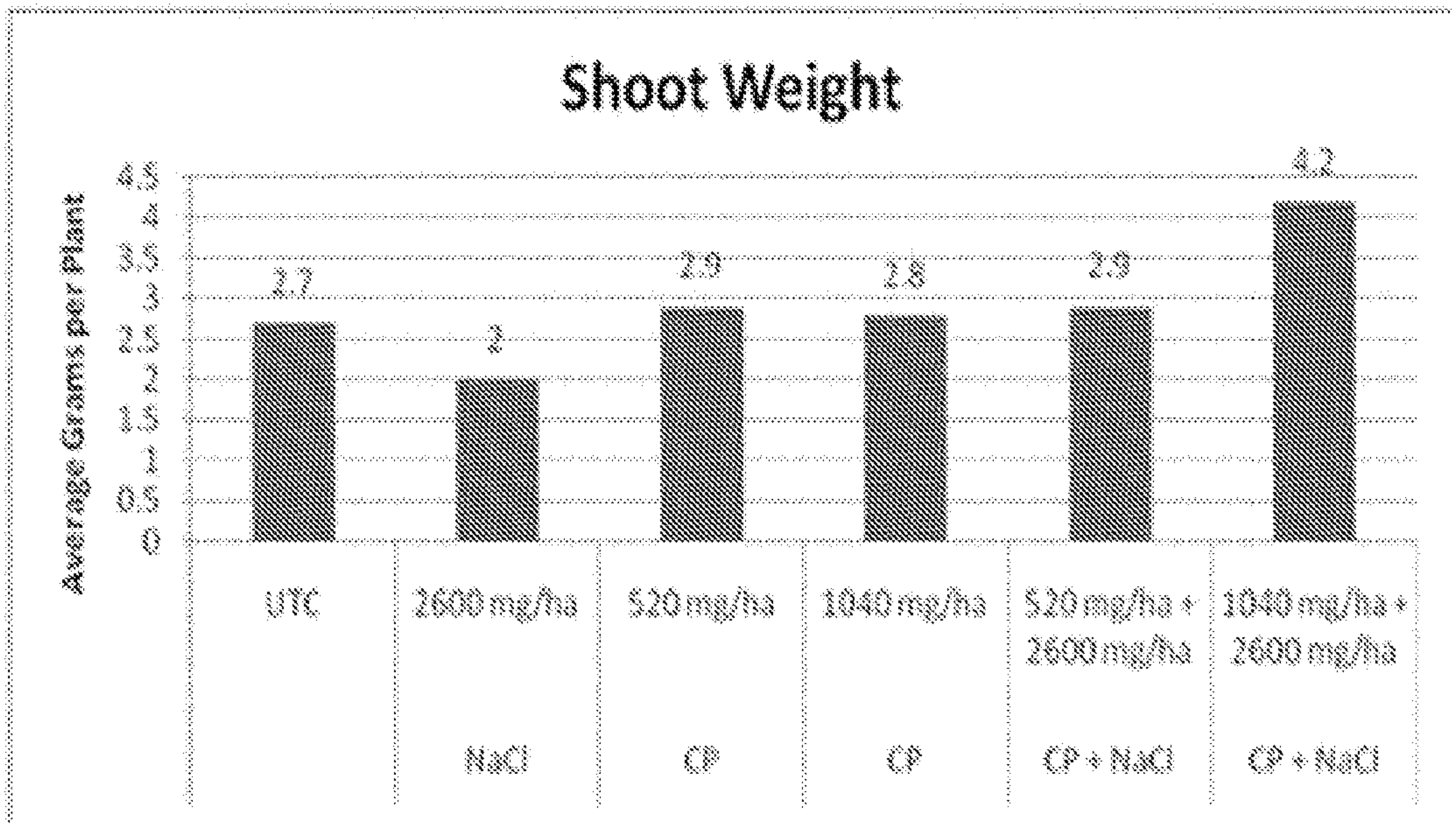
Shoot Weight
Average Grams per Plant
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2.7
2
2.9
2.8
2.9
4.2
UTC
2600 mg/ha
NaCl
520 mg/ha
CP
1040 mg/ha
CP
520 mg/ha + 2600 mg/ha
CP + NaCl
1040 mg/ha + 2600 mg/ha
CP + NaCl

FIG. 5

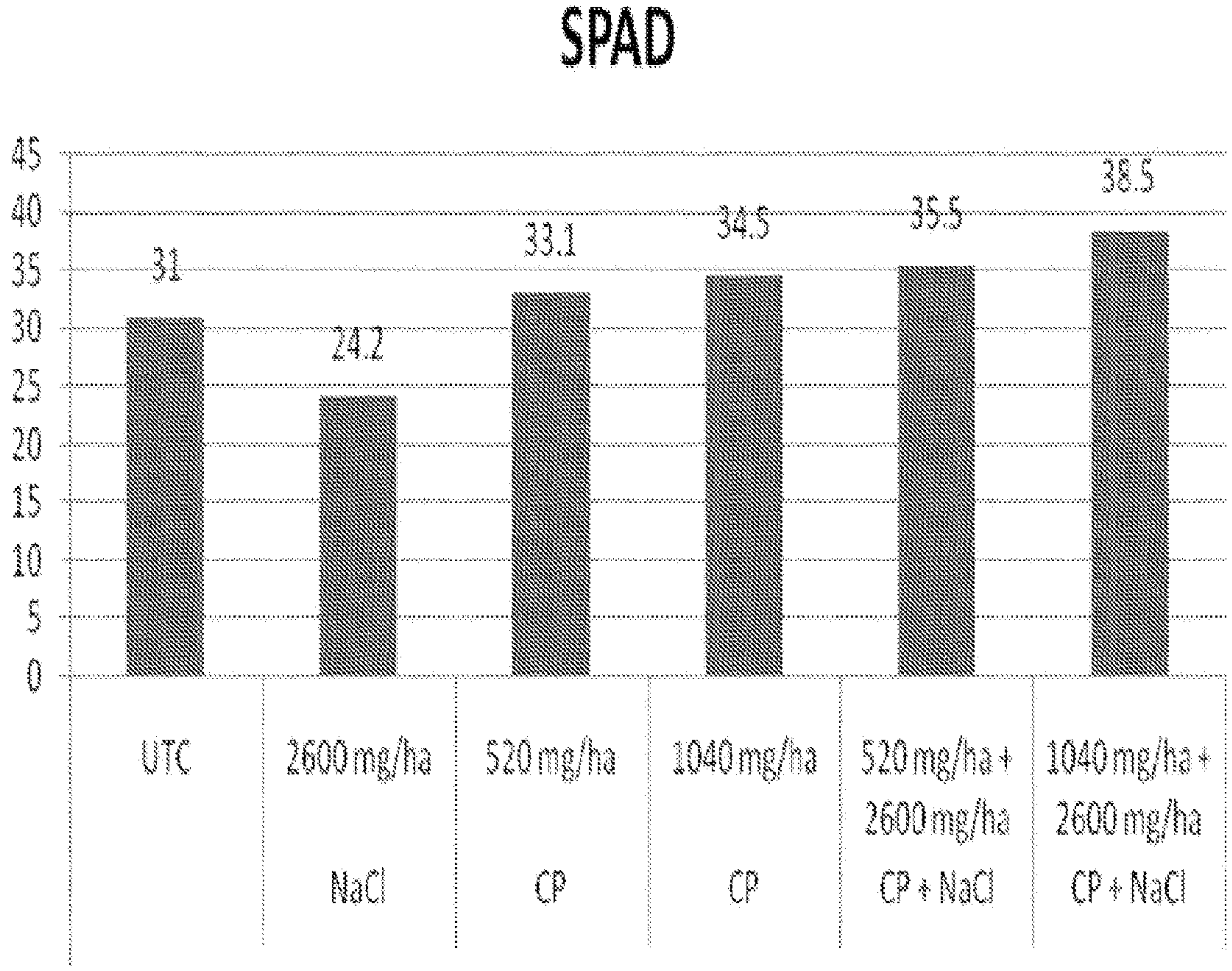
SPAD
45
40
35
30
25
20
15
10
5
0
31
24.2
33.1
34.5
35.5
38.5
UTC
2600 mg/ha NaCl
520 mg/ha CP
1040 mg/ha CP
520 mg/ha + 2600 mg/ha CP + NaCl
1040 mg/ha + 2600 mg/ha CP + NaCl

FIG. 6

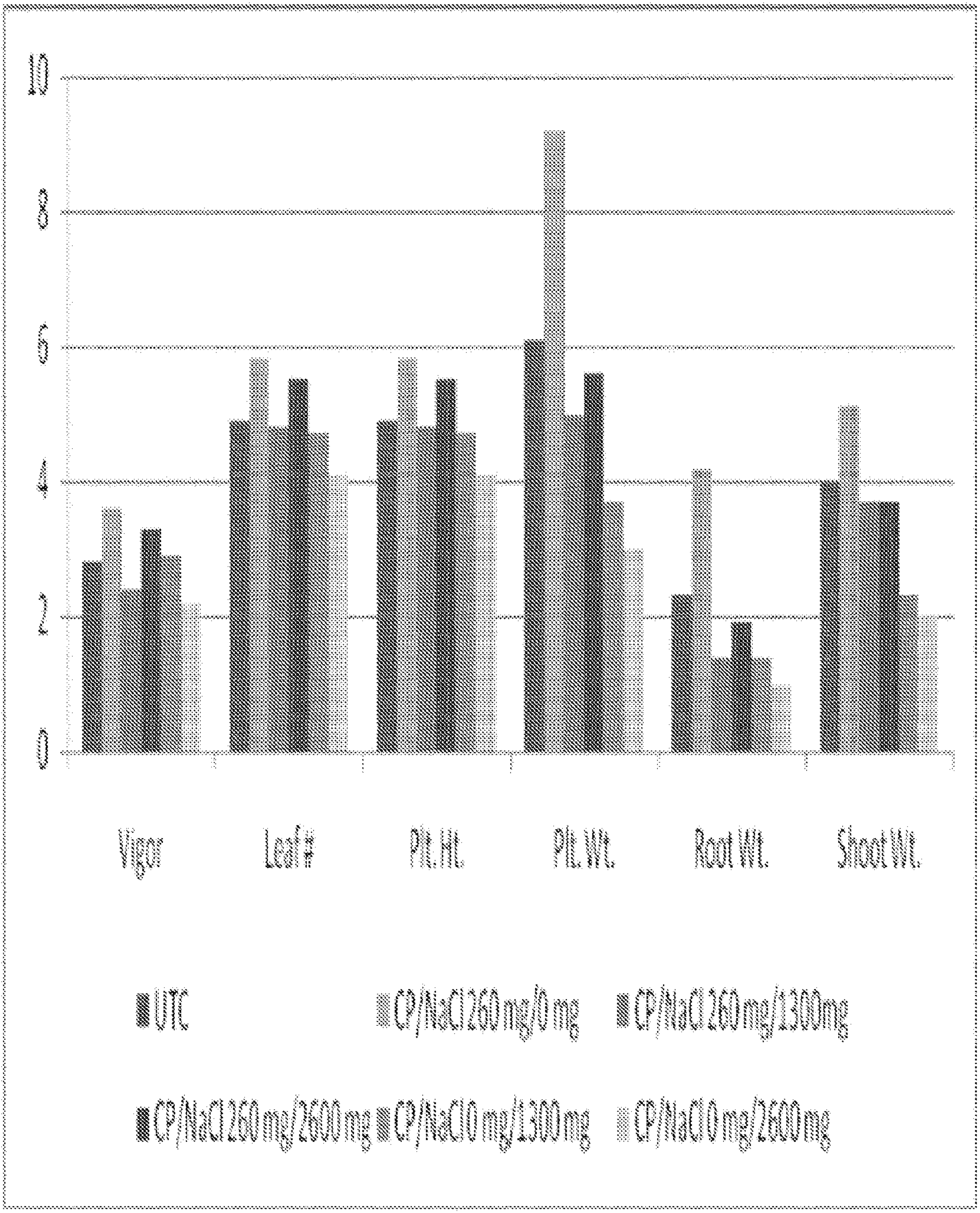
10
8
6
4
2
0
Vigor
Leaf #
Plt. Ht.
Plt. Wt.
Root Wt.
Shoot Wt.
UTC
CP/NaCl 260 mg/0 mg
CP/NaCl 260 mg/1300mg
CP/NaCl 260 mg/2600 mg
CP/NaCl 0 mg/1300 mg
CP/NaCl 0 mg/2600 mg

FIG. . 7

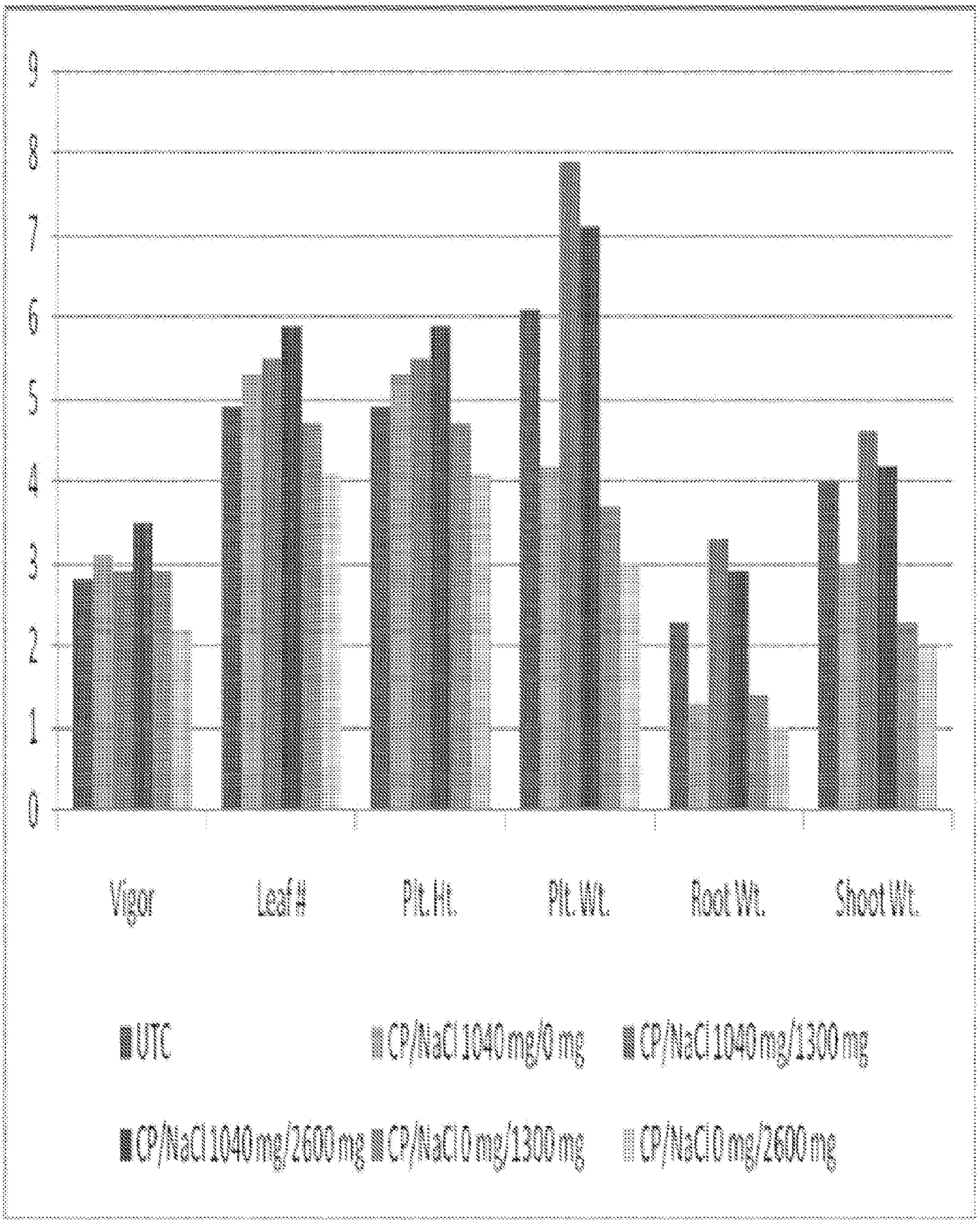
9
8
7
6
5
4
3
2
1
0
Vigor
Leaf #
Plt. Ht.
Plt. Wt.
Root Wt.
Shoot Wt.
UTC
CP/NaCl 1040 mg/0 mg
CP/NaCl 1040 mg/1300 mg
CP/NaCl 1040 mg/2600 mg
CP/NaCl 0 mg/1300 mg
CP/NaCl 0 mg/2600 mg

FIG. 8

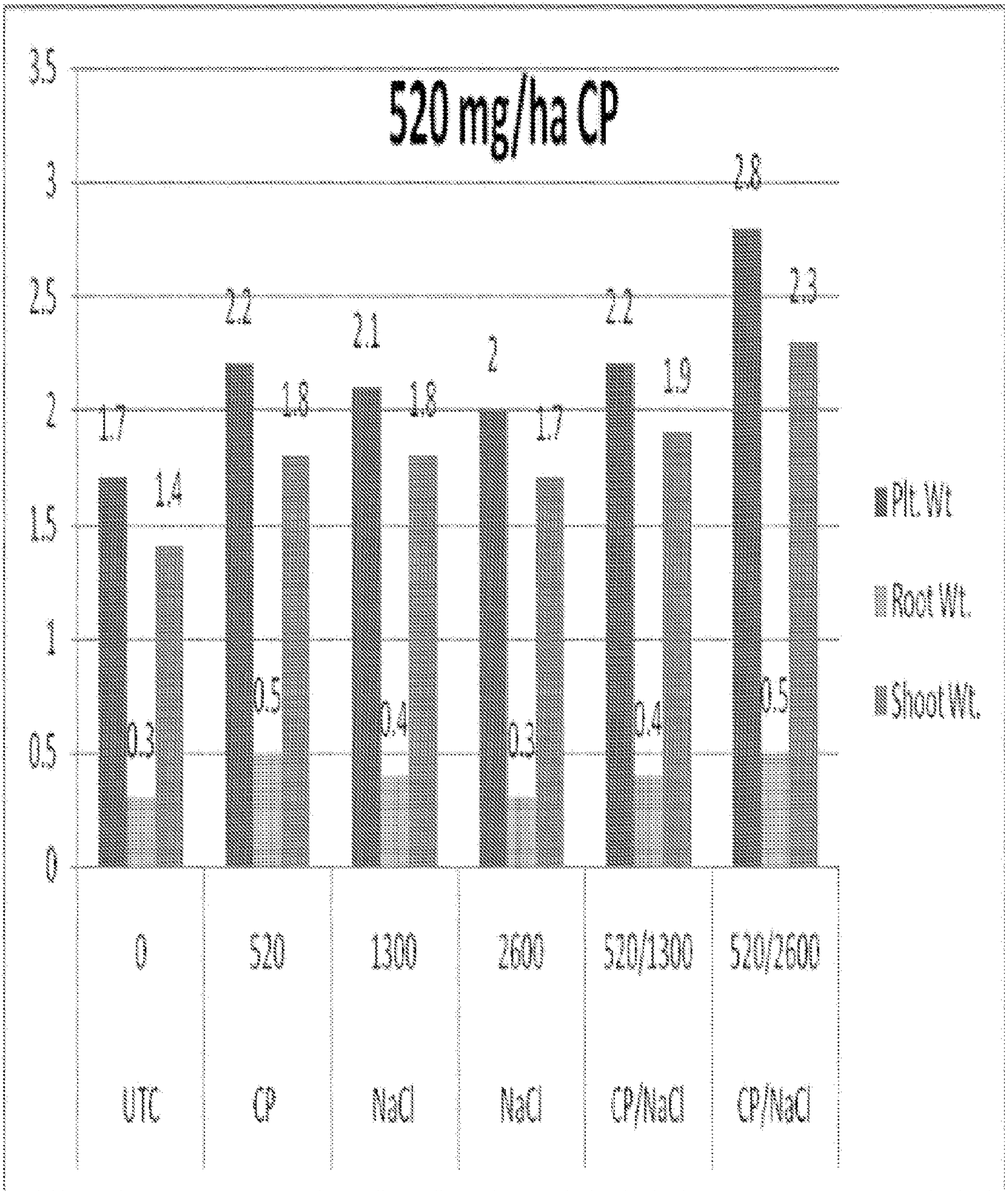
520 mg/ha CP
3.5
3
2.5
2
1.5
1
0.5
0
1.7
0.3
1.4
2.2
0.5
1.8
2.1
0.4
1.8
2
0.3
1.7
2.2
0.4
1.9
2.8
0.5
2.3
▩ Plt. Wt
▩ Root Wt.
▩ Shoot Wt.
0
UTC
520
CP
1300
NaCl
2600
NaCl
520/1300
CP/NaCl
520/2600
CP/NaCl

FIG. 19

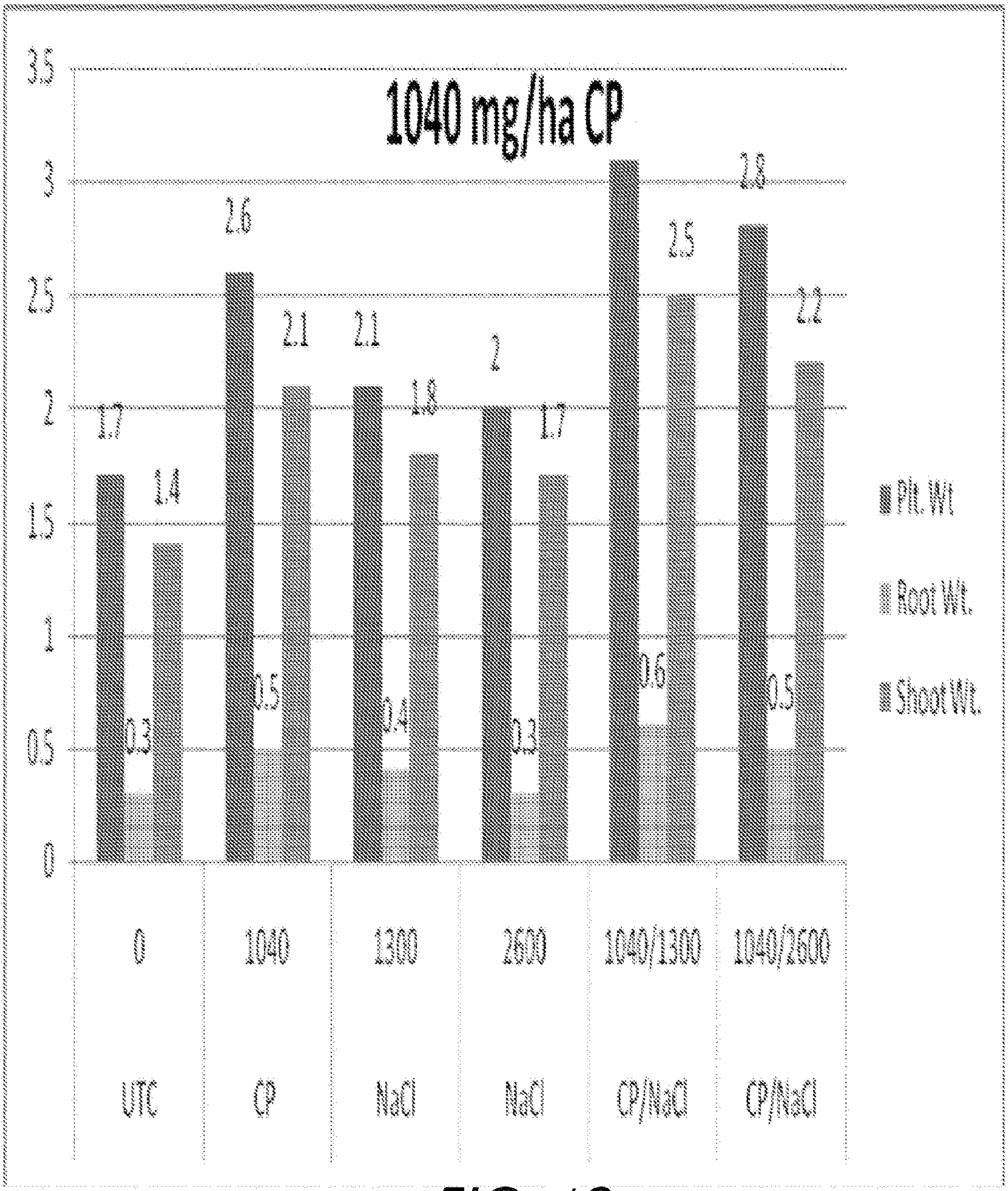
1040 mg/ha CP
3.5
3
2.5
2
1.5
1
0.5
0
1.7
0.3
1.4
2.6
0.5
2.1
2.1
0.4
1.8
2
0.3
1.7
3.1
0.6
2.5
2.8
0.5
2.2
0
UTC
1040
CP
1300
NaCl
2600
NaCl
1040/1300
CP/NaCl
1040/2600
CP/NaCl
Plt. Wt
Root Wt.
Shoot Wt.

FIG. 10