ASSESSMENT OF TOXICITY OF VARIOUS CARBON AND BORON NANOTUBES ON WHEAT AND BARLEY GERMINATION

by

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ABSTRACT

ASSESSMENT OF TOXICITY OF VARIOUS CARBON AND BORON NANOTUBES ON WHEAT AND BARLEY GERMINATION

In previous studies nanotubes effects on seed germination, root elongation, stem length, and vegetative biomass criterias have been examined with different carbon nanotubes and concentrations. In some of these studies it is claimed that multi-walled carbon nanotubes can significantly promote cell elongation in the root system resulting in faster root growth and higher biomass production. Additionally, in some of other studies it is claimed that multi-walled carbon nanotubes have toxic effects on plants. This study has a crucial importance about to be the first study of measuring the boron nanotubes effects and toxicity on plant germination. In literature we couldn't find any study that measuring boron nanotubes effects on plants. In this study, it was assessed possible toxic effects of 80 mg/L (the average concentration in previous experiments) concentration of single-walled carbon nanotubes (SWCNT), multi-walled carbon nanotubes (MWCNT), carboxylated multi-walled carbon nanotubes (MWCNT-COOH) and multi-walled boron nitride nanotubes (MWBNNT) on barley (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L.) germination parameters. The obtained germination results showed that there were no adverse effects on barley and wheat germination in the tested various carbon and boron nanotubes compared to the untreated control group.

ÖZET

ÇEŞİTLİ KARBON VE BOR NANOTÜPLERİN BUĞDAY VE ARPA ÇİMLENMESİNDE TOKSİK ETKİSİNİN DEĞERLENDİRİLMESİ

Evvelki çalışmalarda farklı karbon nanotüp çeşitleri ve konsantrasyonlarıyla, nanotüplerin tohum çimlenmesi, kök uzaması, gövde uzunluğu, bitkisel biyokütle kriterleri incelenmiştir. Bu çalışmaların bazılarında çoklu duvarla çevrili karbon nanotüplerin kök sistemindeki hücre uzamasını teşvik ederek, hızlı kök büyümesi ve yüksek biyokütle üretiminde etkili olduğu iddia edilmektedir. Bunun yanı sıra diğer çalışmaların bazılarında ise çoklu duvarla çevrili karbon nanotüplerin bitkiler üzerinde toksik etkilerinin olduğu öne sürülmektedir. Bu çalışma, boron nanotüplerin bitkiler üzerine etkileri ve toksisitesini inceleyen ilk araştırma olması açısından çok büyük önem taşımaktadır. Bu çalışmada geçmiş araştırmaların ortalama konsantrasyonu olan 80 mg/L konsantrasyonunda tek duvarla çevrili karbon nanotüp (SWCNT), çoklu duvarla çevrili karbon nanotüp (MWCNT), karboksil grubu eklenmiş çoklu duvarla çevrili karbon nanotüp (MWCNT-COOH) ve çoklu duvarla çevrili bor nitrit nanotüp (MWBNNT) kullanılarak, bunların arpa (*Hordeum vulgare* L.) ve buğday (*Triticum aestivum* L.) türlerinin çimlenme parametreleri üzerine olası toksik etkileri incelenmiştir. Elde edilen çimlenme sonuçları, test edilen çeşitli karbon ve bor nanotüplerinin, uygulama yapılmamış kontrol gruplarıyla karşılaştırıldığında, arpa ve buğday çimlenmesi üzerine herhangi bir yan etkilerinin bulunmadığını göstermiştir.

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1. GENERAL INTRODUCTION

1.1. NANOTECHNOLOGY

1.1.1. General Introduction

Nanotechnology has become as one of the developing industry with several implementation on several areas as materials, energy, manufacturing, health care, and medical diagnosis [1-5]. Nanomaterials are known as a derivation of nanotechnology[1,4]. It is estimated approximately 800 products take place in the global market [1,5-7].

Generally, nanomaterials range from 10 to 1000 nm and they have high surface-to-volume ratio [1,4–5]. The nanomaterials has many classification areas as carbonaceous [1,8], semiconductor, metal oxides [1,9, 10], lipids [1,11], zero-valent metals [1,12], quantum dots, nanopolymer [1,13], and dendimers [1,14], with different kinds of features, such as nanofibers, nanowires, and nanosheets.

1.1.2. Nanotubes

Nanotubes are in the form of powder or black soot but fundamentally they are rolled-up sheets of graphene that form hollow strands with walls that are one atom thick. Nanotubes, which are sometimes called buckytubes, were developed from the Fullerene, a structure that is similar to the geodesic domes [16] (Figure 1.1).

Nanotubes, which are grown in a laboratory, are strong and exhibit many thermal and electrical properties that are desirable to chip makers. Carbon nanotubes have the potential to be used as semiconductors, for example, potentially replacing silicon in a wide variety of computing devices [16].

Nanotubes can be characterized by their number of concentric cylinders, cylinder radius and cylinder length. Some nanotubes have a property called chirality, an expression of longitudinal twisting. Multiple nanotubes can be assembled into microscopic mechanical systems called nanomachines [16].

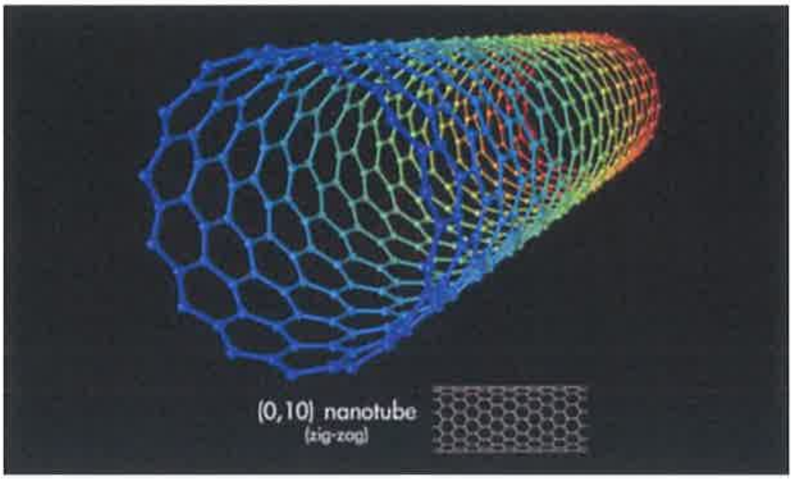


Figure 1.1. (0,10) nanotube (zig-zag) (taken from Thermopower Waves: MIT Scientists Discover New Way to Produce Electricity, 2010).

1.1.3. Carbon Nanotubes (CNTs)

In the past the researches on carbon nanotubes were mainly on their physical specialities [17]. The macromolecular carbon allotropes size and sustainable evolution of the areas of scanning tunneling microscopy and also to conduct precise investigations of individual molecules became possible by electron microscopy [17]. The carbon nanotubes show the metallic conductivity at the same time as: a) chemical and thermal stability, b) elasticity and high tensile strength, c) gas absorbing ability as nanocapillaries, d) solubility and e) chemical functionalization potential ability [17]. Carbon nanotubes can be shared into two branches as single-walled nanotubes SWNTs and multi-walled nanotubes MWNTS[17].

1.1.3.1. Single-Walled Carbon Nanotubes (SWCNTs)

SWCNTs has monomolecular character, simple structure and easy handling for chemical functionalization because of these properties SWCNTs become attractive [17] (Figure 1.2).

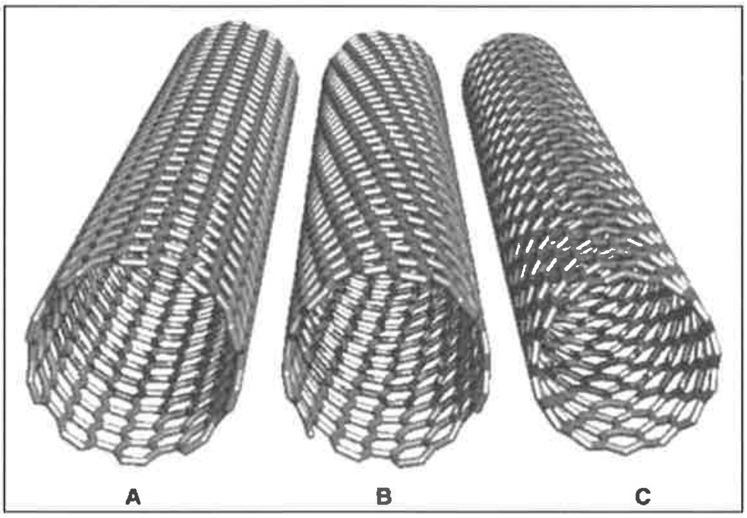


Figure 1.2. Idealized representation of defect-free (n,m) SWNTs with open ends. A) A metallic conducting (10,10) tube ("armchair"), B) a chiral, semiconducting (12,7) tube and C) a conducting (15,0) tube ("zigzag"). The armchair (A) and zigzag (C) tubes are archiral. All the *(n,n)* armchair tubes are metallic, whilst this is only the case with chiral or zigzag tubes if *(n-m)*/3 is a whole number, otherwise, they are semiconductors (taken from A. Hirsch, "Functionalization of Single-Walled Carbon Nanotubes" Angewandte Chemie, vol. 41, no. 11, pp. 1853–1859, 2002.)

1.1.3.2. Multi-Walled Carbon Nanotubes (MWCNTs)

Multi-walled carbon nanotubes (MWCNT) are manufactured nanomaterials with a wide range of commercial fields [18].Multi-wall nanotubes can appear either in the form of a coaxial assembly of SWNT similar to a coaxial cable, or as a single sheet of graphite rolled into the shape of a scroll [19].The diameters of MWNT are typically in the range of 5 nm to 50 nm [19]. The interlayer distance in MWNT is close to the distance between graphene layers in graphite [19]. MWNT are easier to produce in high volume quantities than SWNT (Figure 1.3). However, the structure of MWNT is less well understood because of its greater complexity and variety. Regions of structural imperfection may diminish its desirable material properties [19].

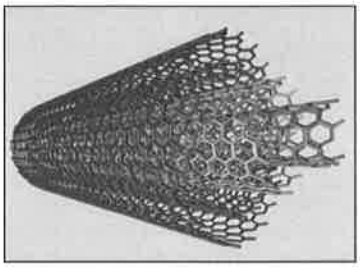


Figure 1.3. Multi-walled carbon nanotube (taken from Royal Society of Chemistry: EU ministers call for nanomaterial ban, 2010)

1.1.3.3. Carboxylated Multi-Walled Carbon Nanotubes (COOH-MWCNTs)

MWCNTs can be effectively purified by oxygen containing groups, generally carboxyl to increase the solubility by repressing impurities from MWCNTs [20] (Figure 1.4).

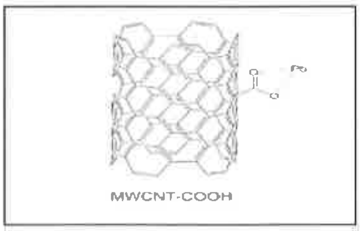


Figure 1.4. Multi-walled carbon nanotube-COOH (taken from Bulletin of the Korean Chemical Society (BKCS): Kinetic and Equilibrium Study of Lead (II) Removal by Functionalized Multiwalled Carbon Nanotubes with Isatin Derivative from Aqueous Solutions, 2013)

1.1.3.4. Boron

Boron is a chemical element with symbol B and atomic number 5. Because boron is produced entirely by cosmic ray spallation and not by stellar nucleosynthesis, it is a low-abundance element in both the Solar system and the Earth's crust. Boron is concentrated on Earth by the water-solubility of its more common naturally occuring compounds, the borate minerals. These are mined industrially as evaporites, such as borax and kernite. The largest proven boron deposits are in Turkey, which is also the largest producer of boron minerals [29] (Figure 1.5.).

Figure 1.5. β-rhombohedral boron (most thermodynamically stable allotrope)[31]

Chemically uncombined boron, which is classed as a metalloid, is found in small amounts in meteroids, but is not found naturally on Earth. Industrally, very püre boron is produced with difficulty, as boron tends to form refractory materials containing small amounts of carbon or other elements. Several allotropes of boron exist: amorphous boron is a Brown powder, and crystalline boron is black, extremely hard (about 9.5 on the Mohs scale), and a poor conductor at room temperature. The primary use of elemental boron is to make boron filaments, which are used in a similar way to carbon fibers in some high-strength materials. Almost all boron use is as chemicaş compounds. About half of global consumption of boron compounds is as additives for glass fibers in boron-containing fiberglass used for insulation or as structural materials. The next leading use is to make boron polymers and ceramics, that play speciliazed roles as high-strength lightweight structural and refractory materials. Borosilicate glass glassware is used for its greater strength and breakage resistance (thermal shock resistance) than ordinary soda lime glass. Boron compounds are also used as fertilizers in Agriculture, and in sodium perborate bleaches. In minor uses, boron is an important dopant for semiconductors, and boron containing reagents are used as intermediates in the synthesis of organic fine chemicals. A few boron-containing organic pharmaceuticals are used, ora re in study. Natural boron is composed of two stable isotopes, one of which (boron-10) has a number of uses as a neutron-capturing agent. In biology, borates have low toxicity in mammals (similar to table salt), but are more toxic to artropods anda re used as insecticides. Boric acid is mildly antimicrobial, and a natural boron—ontaining organic antibiotics is known. Boron is essential to life. Small amounts of boron necessary in soils. Experiments indicate a role for boron as an ultratrace element in animals, but its role in animal physiology is unknown [30].

1.1.3.5. Boron Nitride

Boron nitride is a chemical compound with chemical formula BN, consisting of equal numbers of boron and nitrogen atoms. BN is isoelectronic to a similarly structured carbon lattice and thus exists in various crystalline forms. The hexagonal form corresponding to graphite is the most stable and softest among BN polymorphs, and is therefore used as a lubricant and an additive to cosmetic products. The cubic (sphalerite structure) variety analogous to diamond is called c-BN. Its hardness is inferior only to diamond, but its thermal and chemical stability is superior. The rare wurtzite BN modification is similar to lonsdaleite and may even be harder than the cubic form. Because of excellent thermal and chemical stability, boron nitride ceramics are traditionally used as parts of high-temperature equipment. Boron nitride has potential use in nanotechnology. Nanotubes of BN can be produced that have a structure similar to that of carbon nanotubes, i.e. graphene (or BN) sheets rolled on themselves, but the properties are very different.

Boron nitride has been produced in amorphous (a-BN) and crystalline forms. The most stable crystalline form is the hexagonal one, also called h-BN, α-BN, or g-BN (graphitic BN). It has a layered structure similar to graphite. Within each layer, boron and nitrogen atomsa re bound by strong covalent bonds, whereas the layers are held together by weak van der Waals forces. The interlayer ''registry'' of these sheets differs, however, from the pattern seen for graphite, because the atoms are eclipsed, with boron atoms lying over and above nitrogen atoms. This registry reflects the polarity of the B-N bonds. Still, h-BN and graphite are very close neighbors an deven the BC6N hybrids have been synthesized where carbon substitutes for some B and N atoms [32].

As diamond is less stable than graphite, cubic BN is less stable than h-BN, but the conversion rate between those forms is negligible at room temperature (again like diamond). The cubic form has the sphalerite crystal structure, the same as that of diamond, and is also called β-BN or c-BN. The wurtzite BN form (w-BN) has ther same structure as lonsdaleite, a rare hexagonal polymorph of carbon. In both c-BN and w-BN boron and nitrogen atomsa re grouped into tetrahedra, but the angles between neighboring tetrahedra are different [33].

1.1.3.6. Boron Nitride Nanotubes

Boron nitride nanotubes were predicted in 1994 and experimentally discovered in 1995 [34]. They can be imagined as a rolled up sheet of boron nitride. Structurally, it is a close analog of the carbon nanotube, namely a long cylinder with diameter of several to hundred nanometers and length of many micrometers, except carbon atomsa re alternately substituted by nitragen and boron atoms. However, the properties of BN nanotubes are very different: whereas carbon nanotubes can be metallic or semiconducting depending on the Rolling direction and Radius, a BN nanotube is an electrical insulator with a bandgap of ~5.5 eV, basically independent of tube chirality and morphology [35]. In addition, a layered BN structure is much more thermally and chemically stable than a graphitic carbon structure. [36,37] All well-established techniques of carbon nanotube growth, such as arc-discharge, [35,39] laser ablation [41][42] and chemical vapor deposition, [43] are used to synthesize BN nanotubes. BN nanotubes can also be produced by ball milling of amorphous boron, mixed with a catalyst: iron powder, under NH3 atmosphere. Subsequent annealing at ~1100 °C in nitrogen flow transforms most of the product into BN [43][44]. A high temperature/high pressure method is also being utilized to produce BN nanotubes [45]. Electrical and field emission properties of such nanotubes can be tuned by doping with gold atoms via sputtering of gold on the nanotubes [43][46]. Doping rare-earth atoms of europium turns a BN nanotube into a phosphor material emitting visible light under electron excitation [44]. Quantum dots formed from 3-nanometer gold particles spaced across the nanotubes exhibit the properties of field-effect transistors at room temperature [47]. Like BN fibers, boron nitride nanotubes Show promise for aerospace applications where integration of boron and in particular the light isotope of boron (10B) into structural materials improves both their strength and their radiation-shielding properties; the improvement is due to strong neutron absorption by 10B. Such 10BN materials are of particular theoratical value as composite structural materials in the future manned interplanetary spacecraft, where absorption-shielding from cosmic ray spallation neutrons is expected to be a particular asset in light construction materials [48]. BN nanotubes have also shown potential in certain cancer treatments [49].

1.2. GERMINATION PHYSIOLOGY AND NANOTUBE EFFECTS

1.2.1. General Introduction

In the living life the used and commercialized nanomaterials count are more then 1300 [1]. In 1985, carbon nanotubes and related materials have been discovered and the worlwide production of nanomaterials have been reached to 1500 tons per year in 2011 [1].

In previous studies, the effects of nanotubes have been investigated on plant growth and many kind of nanotubes, specially the derivatives of carbon nanotubes as MWCNTs and SWCNTs have been tested on seed germinaton. In recent researches it is focused on the impact of nanotubes on crop improvement and many variation of nanomaterials has been evaluated in terms of their absorption, translocation, accumulation and effects on growth and development in array of crop plants [22,23].

1.2.2. Physiological Changes During and Following Germination

Germination is initiated by the uptake of water. This results in dormant grain becoming vigorously metabolic and resuming protein and nucleic acid synthesis [26]. Water enters through the micropylar region and penetrates to the rest of the grain [27]. Germination is considered to be complete when the coleorhiza emerges from the grain [26]. At this point the grain has clearly defined root and shoot systems. Following germination, the coleoptile breaks through the testa and grows down the dorsal side of the grain [26,27]. The reserves of the starchy endosperm are broken down by a battery of enzymes released from the scutellum and aleurone layer, and also by enzymes present in the starchy endosperm of the mature grain. Degredation products are translocated from the starchy endosperm through the scutellum, to support the growth of embryo and the young seedling. In the ensuing sections the changes that occur within the scutellum, aleurone and starchy endosperm following the initiation of germination will be briefly considered.

1.2.3. Carbon Nanotubes Effects On Seed Germination

In one of the previous studies, it is claimed that multi-walled carbon nanotubes can enhance root elongation of wheat and the effectivity of MWCNTs in root system pretends to improve activity of root dehydrogenase and leading a faster root growth and higher biomass production on wheat [22,23]. In an other study, phytotoxicity of five nanomaterials including MWCNTs have been tested and as a result it has been claimed the existence of MWCNTs significantly decreased biomass relative to controls or corresponding bulk materials and they have no effect on root elongation [24]. (Table 1.2.1.)

Table 1. 1. Effect of Carbon nanomaterials on plants

Nanoparticle	Size (nm)	Plant	Concentration	Effect	References
C_{60} Fullerenes	1450-1900	Corn	500 mg/kg	Reduced biomass	[53]
		Soybean		Reduced biomass	[53]
Fullerol ($C_{60}(OH)_{20}$)	1.5 ± 0.2-5.00 ± 0.7	Bitter melon	0.943, 4.72, 9.43, 10.88 and 47.20 nm	Increased biomass yield, water content, fruit length, fruit number, and fruit fresh weight, increased two antidiabetic phytomedicines, charantin and insulin	[54]
Functionalized carbon nanotube	8	Lettuce	104, 315, 1750 mg/L	Reduced root length at longer exposure	[51]
Functionalized single-walled carbon nanotube	8	Cabbage, carrot, lettuce, onion, tomato	9, 56, 315, 1750 mg/L	No effect	[51]
Multiwalled carbon nanotube		Zucchni	1000 mg/L	Reduced biomass	[55]
		Lettuce	2000 mg/L	Reduced root length	[56]
	Diameter range:10-30	Rice	20,40, 80 mg/L	Chromatin condensed inside the cytoplasm and caused cell death, plasma membrane detachment from cell wall and cell shrinkage	[57]

		Tomato	10-40 mg/L	Significant increase in germination rate, fresh biomass, and length of stem significantly, enhanced moisture content inside tomato seeds	[58]
		Corn, cucumber, radish, rapeseed, ryegrass, lettuce	2000 mg/L	No effect on germination	[56]
		Ryegrass	2000 mg/L	Increased root length	[56]
		Zucchni		No effect on the germination	[55]
	Internal dimension 110-170	Wheat	100 mg/L	No significant effect on root or shoot growth	[59]
	10_25	Tomato	50-200µg/L	Significant increase in plant height, flower and fruit formation	[60]
Single-walled carbon nanotube	1.19 (major), 18, 722	Rice	400 mg/L	Delayed flowering, decreased yield	[61]
	8	Tomato	104, 315, 1750 mg/L	Most sensitive in root reduction	[51]
	8	Cucumber, onion	104, 315, 1750 mg/L	Increased root length	[51]
	8	Cabbage, carrot, lettuce	104, 315, 1750 mg/L	No effect	[51]

1.3. AIM OF THE STUDY

In previous studies nanotubes effects on seed germination, root elongation, stem length, and vegetative biomass criterias have been examined with different carbon nanotubes and concentrations. In some of these studies it is claimed that multi-walled carbon nanotubes can significantly promote cell elongation in the root system and increase the dehydrogenase activity, resulting in faster root growth and higher biomass production. Additionally, in some of other studies it is claimed that multi-walled carbon nanotubes have toxic effects on plants.

In this study we are aiming at getting answers for some of unknown questions about toxicity of various carbon and boron nanotubes on some selected crops. We are planning to evaluate the effects of some various nanotubes as MWCNTs, single-walled (SWCNT), multi-walled (MWCNT), carboxylated multi-walled carbon nanotubes (MWCNT-COOH) and multi-walled boron nitride nanotubes (MWBNNT) on barley (Hordeum vulgare L.) and wheat (Triticum aestivum L.) germination. We used barley and wheat as the model crops because of widespread use of studies and commercial importance in all over the world.

In this thesis we are taking a part attention to seven days germination periods of wheat and barley seeds and in this developing period the application methods of nanotubes. In the previous studies some effects of MWCNTs and SWCNTs were assessed but in this study together with these materials we used our Yeditepe University nanotechnology laboratory's synthesised MWBNNT production. It is never experienced before in previous researches. Our aim is to understand the effects of different type of carbon nanotubes and boron nanotubes by comparing them at the same level of concentrations on seed germination parameters as germination percentage, shoot and root elongation and shoot and root biomass and also to determine the accumulation of boron levels with ICP method.

We expect to find a result about carbon nanotubes if they are enhancing the root and shoot elongation we desired to test it about poor background of previous studies and also about less number of existing studies. Additionally, MWBNNTs are never tested before and we expect to find even if using the MBNNTs in the same concentration with the other carbon nanotubes and we are trying to answer two question if it is an alternative of CNTs for increasing root, shoot elongation and the biomass of plant or if it has a toxic or non-toxic effect on barley and wheat seeds germination in the same concentration with carbon nanotubes.

2.MATERIALS

2.1. CHEMICALS

There are two type of seeds in this experiment. Tested wheat the species were Krasunia Odeska (bread type wheat) and Nota (bread type wheat) from Marmara Tohum Geliştirme A.Ş., the other barley the species Scarpia (fodder barley) from Marmara Tohum Geliştirme A.Ş.,, Sloop type from Australia (malt barley) and Tokak 157/37 (malt barley), 99,8% ethanol (C_2H_5OH), 4% NaClO, sterilized pure water, 95% ethyl alcohol is used for general experiment field sterilization, MWCNTs were purchased from Sigma-Aldrich (purity: 99 %, OD 9 Length 6–13 nm 9 2.5–20 lm). H_2SO_4, HNO_3 is used for carboxylated- MWCNT preparation, SWCNTs were purchased from Sigma-Aldrich (purity: 95 % (carbon as SWCNT diameter 0.6-1.1 nm density 1.7-1.9 g/cm^3 at 25 °C(lit.)), MWBNNTs are received from Yeditepe University Nanotechnology Laboratory (Colemanite ($Ca_2B_6O_{11}\cdot 5H_2O$) has been used for the synthesis of MWBNNTs). Colemanite ($Ca_2B_6O_{11}\cdot 5H_2O$) was a gift from Eti Mine Works General Management (Turkey). Iron (III) oxide, iron (II, III) oxide, aluminum oxide, zinc oxide, hydrochloric acid, and nitric acid were provided from Sigma. Highly pure NH_3 gas (99.98%) was provided from Schick GmbH & Co. KG. All solutions were prepared with deionized (DI) water. HNO_3 in 5% concentration was used to dissolve the plant materials for ICP measurement.

2.2. LABORATORY EQUIPMENT

During the whole experiment shaker (BS-T, Sartorius, Aubagne, France), whatman paper, petri dishes, pasteur pipette, pipette tips, centrifuge tubes, sterilized scalpel, centrifuge racks, drying cabinets, aluminum foil, tapes for sterilization, refrigerator, nanofilter tools, forceps, ruler, microcentrifuge (Sigma-Aldrich, Taufkirchen, Germany), autoclave (Hirayama, Saitama, Japan), laminar flow (HFsafe-1200, Heal Force, Shanghai, China), growth chamber (Digitech, Ankara, Türkiye), Bath Sonicator device 2510, XSeries 2 ICP-MS, ICAP 6000 Series ICP Spectrometer, tubular furnace Protherm, Furnaces PTF 14/50/450 were used for ultrasonication of carbon nanotubes.

3. METHODS

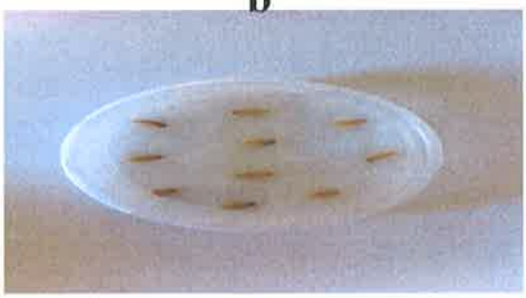
3.1. GENERAL INTRODUCTION

In the thesis, we have studied with wheat and barley species. The study is including four different control groups per each seed species as 1- water control group, 2-SWCNT applied group, 3- COOH-MWCNT applied group 4- MWBNNT applied group. For each group we used 18 petri plates and per each plate we put 10 seeds. The experiment control duration was including 7 days period. After seed selection, surface sterilization of seeds, imbibition duration preparation, whatman paper preparation, COOH-MWCNT media preparation, SWCNT media preparation, MWBNNT media preparation, sterilized pure water preparation, this 7 days observation and application period was started. In this duration we kept the wheat and barley petri dishes in growth cabinet at stabilized 22,23 °C. Before to start this period in the initial day-0 for each group we applied per petri plate 5 ml of assigned media for each group. First day of experiment we applied only 5 ml sterilized pure water per each dishes. At the second day we have selected 3 petri plate from each group and we counted the germinated seeds in every 30 seeds. After counting the seeds and calculating the germination rate of the seeds per each group we measured the maximum length of roots, number of roots and length of shoots for each germinated seed and calculated average root number and root length and we watered the rest of 15 petri dishes per each group with 5 ml sterilized pure water. At the third day again we selected 3 petri plate from each group and we counted the germinated seeds in every 30 seeds. After counting the seeds and calculating the germination rate of the seeds per each group we measured the maximum length of roots, number of roots and length of shoots for each germinated seed and calculated average root number and root length and in the same date we used also this 3 petri dishes to measure dry weights of roots and shoots. The rest of 12 petri dishes watered with 5 ml sterilized pure water. Before measurement dry weight of seed groups, we seperated the roots and shoots with help of sterilized scalpels in germinated ones of 30 seeds for each group and after covering them with aluminum foil seperately, we put them in drying cabinets and after controlling of the driying period (approximately 2 days) we measured the dry shoot and root weights of groups . At day-4 we selected 3 petri plate from each group and we counted the germinated seeds in every 30 seeds. After counting the seeds and calculating the germination rate of the seeds per each group we measured the maximum length of roots, number of roots and length of shoots for each germinated seed and calculated average root number and root length and we applied the rest of 9 plates in each group, we applied per petri plate 5 ml of assigned media for each group as day-0. In the fifth day we selected 3 petri plate from each group and we counted the germinated seeds in every 30 seeds. After counting the seeds and calculating the germination rate of the seeds per each group we measured the maximum length of roots, number of roots and length of shoots for each germinated seed and calculated average root number and root length and the rest of 6 petri plates for each group were watered with 5 ml sterilized pure water. On the sixth day only we watered the 6 petri dishes per each group with 5 ml sterilized pure water (Figure 3.1.).

a

b

c



d

Figure 3.1. The photos from experiments. a-the measurement of root length, b-the measurement of shoot length, c- the seedlings in growth cabinet, d. seed distribution in pot with whatman papers.

And the last day we took the 6 dishes for each group to measure their dry weight and before measurement of dry weight of seed groups, we seperated the roots and shoots with help of sterilized scalpels in germinated ones of 60 seeds for each group and after covering them with aluminum foil seperately, we put them in drying cabinets and after controlling of the drying period (approximately 2 days) we measured the dry shoot and root weights of groups (Figure 3.1.). The dry weights were used to determine boron contents of shoots and roots with ICP technique.

3.1.1. Seed Selection

In the thesis different species of barley (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L.) were tested to select the most appropriate and strong species to pretend highest and unique germination rate. After preliminary for the selection of species we have taken the better results from barley was Tokak 157/37 (malt barley) and from wheat was Krasunia Odeska(bread type wheat) species. Per each experiment we used 18 petri dishes including 10 seeds per each petri plate. Our study consisted four different control group as 1- water control group, 2-SWCNT applied group, 3- COOH-MWCNT applied group 4- MWBNNT applied group for each seed species. Totally we used 360 seeds for wheat experiment and 360 seeds for barley experiment. While the period of choosing the seed samples that we used in the experiment we observed to choose unique physical properties as colour, shape, weight, length for each seed.

3.1.2. Seed Surface Sterilization

After selection of the seed species for (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L.), we applied surface sterilization procedure for barley (Tokak 157/37)(malt type barley)and wheat (Krasunia Odeska) (bread type wheat) species.

For the wheat seeds we put the selected seeds into centrifuge tube and added 99,8 % ethanol and waited for 5 minutes in the ethanol. After filtering the seeds from ethanol we put them in to another centrifuge tube including 4% NaClO for 1 minute. After filtering the wheat seeds we washed them 3 times in sterilized pure water. In the duration of washing we used 3 different centrifuge tubes and each of washing duration was 1 minute to remove the chemicals from the surface.

In seperate centrifuge tubes we used the same sterilization method with wheat for selected barley seeds.

3.1.3. Seed Imbibition Duration Testing

Before applying the seeds on petri dishes we tested the appropriate imbibition hours for the optimum seedling rate. We tried 1h, 5h, 12h and 24 h of imbibition on seeds. Per each imbibition we used 30 seeds and 3 petri plates. At the end of 2 days for wheat seeds, the germination counts were 9/30, 24/30, 21/30 and 15/30, respectively and germination rates were 30 %, 80 %, 70 % and 50 %, respectively. For barley seeds, the germination counts were 6/30, 17/30, 14/30 and 13/30, respectively and germination rates were 20 %, 56 %, 46 %, and 43%, respectively.

According to these results, for the both of wheat and barley species we found the most appropriate imbibition duration as 5 hours for highest germination rate. And in our experiment we used the 5h imbibition duration.

3.1.4. Whatman Filter Paper Preparation

We used whatman filter papers in petri plates for germination of seeds. Before to use them we cut the papers as the same size with used petri dishes and per each petri dishes we used 2 layer of whatman filter papers for petri plates in the size of 60 mm x 15 mm. For wheat seed experiment we used 144 pieces of whatman paper and also for barley experiment we used the same amount and totaly we spent 288 pieces of whatman paper. After preparing the papers we covered them with aluminum foil and autoclaved them for 121 °C, 15 min in autoclave (Hirayama, Saitama, Japan).

3.1.5. COOH-MWCNT Preparation

As in previous studies, MWCNTs were added to a 100 mL 3:1 concentrated H_2SO_4:HNO_3 solution. Then the mixture was ultrasonicated for 8 h, followed by centrifugation to remove larger unreacted impurities from the solution, a thorough rinse with pure water and re-suspended in water by sonication for 20 min.

3.1.6. SWCNT Preparation

SWCNT concentration were used 80 mg/lt. 40 mg SWCNT were poured in 500 ml sterilized pure water and the mixture were put in ultrasonication for 30 minutes for a homogeneous disperse of SWCNT. Before using for experiments this process were repeated.

The used BNNTs were synthesised in Yeditepe University Nanotechnology Laboratory. BNNT synthesis: 2 g of colemanite and 0.166 g Fe_2O_3 were suspended in 2 mL DI water and vortexed until full dispersion [21]. The homogeneous mixture was transferred into an alumina boat. The water was evaporated with pre-heating at 180 °C for 15 min, and the alumina boat was placed into the center of the tubular furnace (Protherm, Furnaces PTF 14/50/450) [21]. The BNNT synthesis was performed under NH_3 atmosphere. The furnace temperature was set to a heating rate of 8 °C/min until 1280 °C and then heated at this temperature for 3 hours [21]. The furnace was left for cooling down to 520 °C, and the reaction boat was removed from the furnace. The BNNTs were collected from the top of alumina BNNTs has been synthesized from unprocessed colemanite for the first time [21]. BNNTs have better characteristics than CNTs as resistance to high temperatures and repressive chemical conditions [21]. The produced BNNTs has taken multi-walled and randomly oriented form by colemanite effect and their diameter length ranges between 10–30 nm and thickness of their wall has 5 nm length [21]. Additionally, simple acid solution treatment method can be used to purify the produced BNNTs and the provided BNNTs can be utilized in many practices as retention of specifc ions, hydrogen storage, and the development of the mechanical as well as the chemical stability of polymer composites [21]. MWBNNT concentration were used 80 mg/lt in the thesis. 40 mg MWBNNT were poured in 500 ml sterilized pure water and the mixture were put in ultrasonication(wise cleaner set 40 khz 100 W) for 2 minutes. Then we put the mixture on shaker and it was shaked for 3 days for a homogenous dispersion without degredation of its structure.

4. RESULTS

4.1. GERMINATION PERCENTAGE RESULTS

In all of each experiment, we used the germination rates of wheat and barley experiments are shown in the Table 4.1 and Figure 4.1. While calculating the germination rate we took 2nd, 3th, 4th, 5th germination dates and for each day 10 seedlings 3 pots and totally the germination percentage was calculated on 120 seeds for each type of plants. In wheat the germination percentage was measured as SWCNT>MWBNNT>COOH-MWCT=WATER CONTROL and in barley, the germination rate was measured as MWBNNT>COOH-MWCNT>WATER CONTROL>SWCNT.

Table 4.1. SWCNT, MWBNNT, and COOH-MWCT application on the germination rates of wheat (Krasunia Odeska) and barley (Tokak 157/37).

WHEAT	**Germination Rate(%)**
COOH-MWCNT	92
SWCNT	95
MWBNNT	94
WATER CONTROL	92
BARLEY	**Germination Rate(%)**
COOH-MWCNT	42
SWCNT	30
MWBNNT	44
WATER CONTROL	38

According to analysis result, the germination rate we took 2nd, 3th, 4th, 5th germination dates and for each day 10 seedlings 3 pots and totally the germination percentage was calculated on 120 seeds. In wheat the germination percentage was measured as SWCNT>MWBNNT>COOH-MWCT=WATER CONTROL and in barley, the germination rate was measured as MWBNNT>COOH-MWCNT>WATER CONTROL>SWCNT

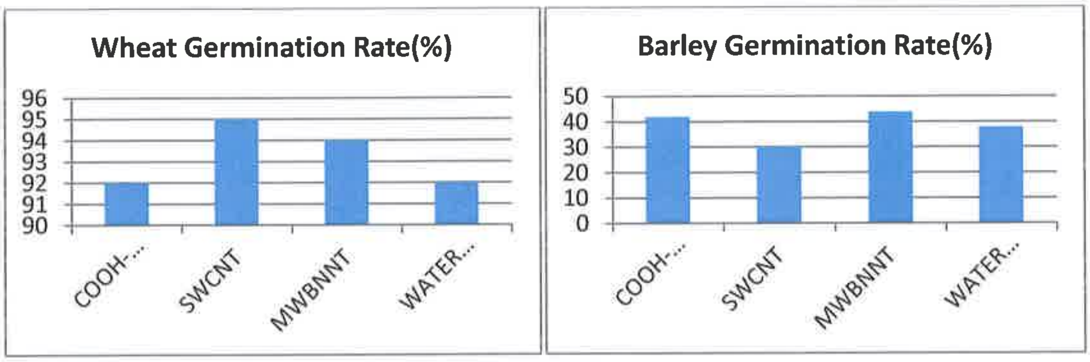


Figure 4.1. SWCNT, MWBNNT, and COOH-MWCT application on wheat (Krasunia Odeska) and Barley (Tokak 157/37) germination rate graphics, respectively.

There was no effective difference germination difference between the applications in the wheat seeds but the highest germination rate was found in SWCNT experiment with 95 %.

In the barley seed experiment the lowest germination rate was found in SWCNT experiment with 30 %.

4.2. ROOT LENGTH, ROOT NUMBER AND SHOOT LENGTH RESULTS OF WHEAT SEED EXPERIMENT

The experiment includes 30 seeds for each day and below we showed the root lengths, root numbers and shoot lengths.In Krasunia Odeska wheat type at the 5th day of germination compared with the control group the root lengths of carbon nanotubes were increased and the increased amounts were virtually same and we saw a little increase of root length in MWBNNTs compared with the control group. When we looked the root numbers compared with the control groups the rooting number were closely same but we saw a little increase in MWBNNT application compared with the control group. In shoot length of wheat the 5th day shooting results showed us these ranking as MWBNNT>COOH-MWCNT>SWCNT>WATER CONTROL. It shows us in wheat boron nanotubes increased the shooting better than carbon nanotubes and carbon nanotubes increased the shooting effects compared with the control group in wheat (Table 4.2., Figure 4.2., Table 4.3., Figure 4.3., Table 4.4., Figure 4.4.,Table 4.5., Figure 4.5.).

Table 4.2. Effects o SWCNT, MWBNNT, and COOH-MWCT application on root length, root number and shoot length of wheat seed

	Root Length			
Treatment, day	**2**	**3**	**4**	**5**
A-Control	37,7	66,1	78,2	97,3
B-COOH-MWCNT	42,5	60,4	82,1	110,6
C-SWCNT	41,5	65,7	89,0	110,7
D-MWBNNT	39,5	60,8	81,7	102,2
	Root Number			
A-Control	3,24	3,48	3,69	3,77
B-COOH-MWCNT	3,04	3,33	3,59	3,8
C-SWCNT	3,00	3,09	3,83	3,82
D-MWBNNT	3,00	3,13	3,95	4,09
	Shoot Length			
A-Control	25,3	33,9	62,1	77,4
B-COOH-MWCNT	25,6	32,7	61,5	85,9
C-SWCNT	25,2	32,6	58,4	82,3
D-MWBNNT	25,5	30,9	62,5	86,0

In Krasunia Odeska wheat type at the 5th day of germination compared with the control group the root lengths of carbon nanotubes were increased and the increased amounts were virtually same and we saw a little increase of root length in MWBNNTs compared with the control group (Figure 4.2.).

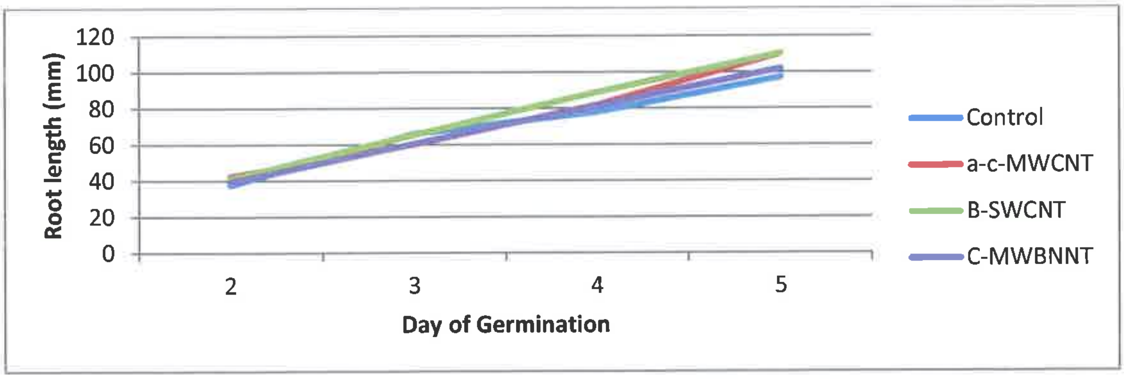


Figure 4.2. Effects of SWCNT, MWBNNT, and COOH-MWCT application on wheat (Krasunia Odeska) root length measurement of control and some selected variety of nanotubes.

The rooting number were closely same but we saw a little increase in MWBNNT application compared with the control group (Figure 4.3.).

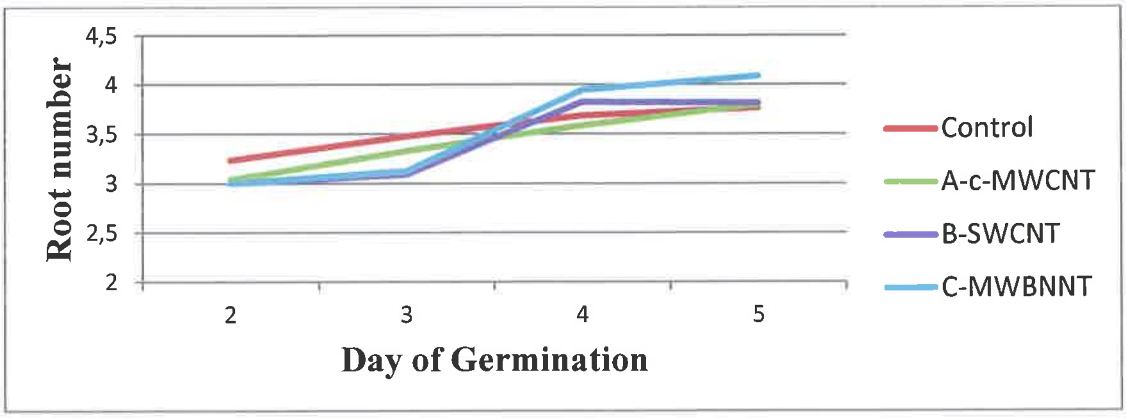


Figure 4.3. Effects of SWCNT, MWBNNT, and COOH-MWCT application on wheat (Krasunia Odeska) root numbers compared with the control groups

In shoot length of wheat the 5th day shooting results showed us these ranking as MWBNNT>COOH-MWCNT>SWCNT>WATER CONTROL. It shows us in wheat boron nanotubes increased the shooting better than carbon nanotubes and carbon nanotubes increased the shooting effects compared with the control group in wheat (Figure 4.2.3.).

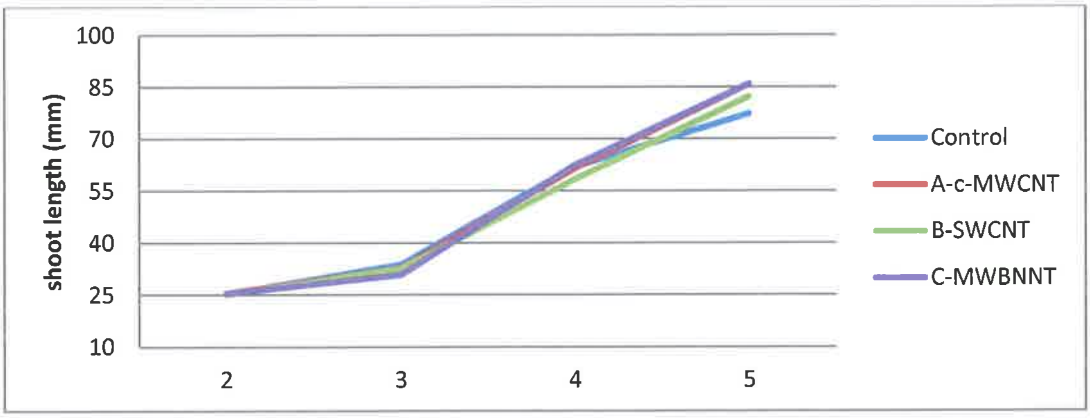


Figure 4.4. Effects of SWCNT, MWBNNT, and COOH-MWCT application on shoot length of wheat the 5th day shooting results

The 5th day of germination rates of wheat were measured. In SWCNT we found a significant increase. Also there was a low increase in MWBNNT experiment on wheat germination rates (Figure 4.5.).

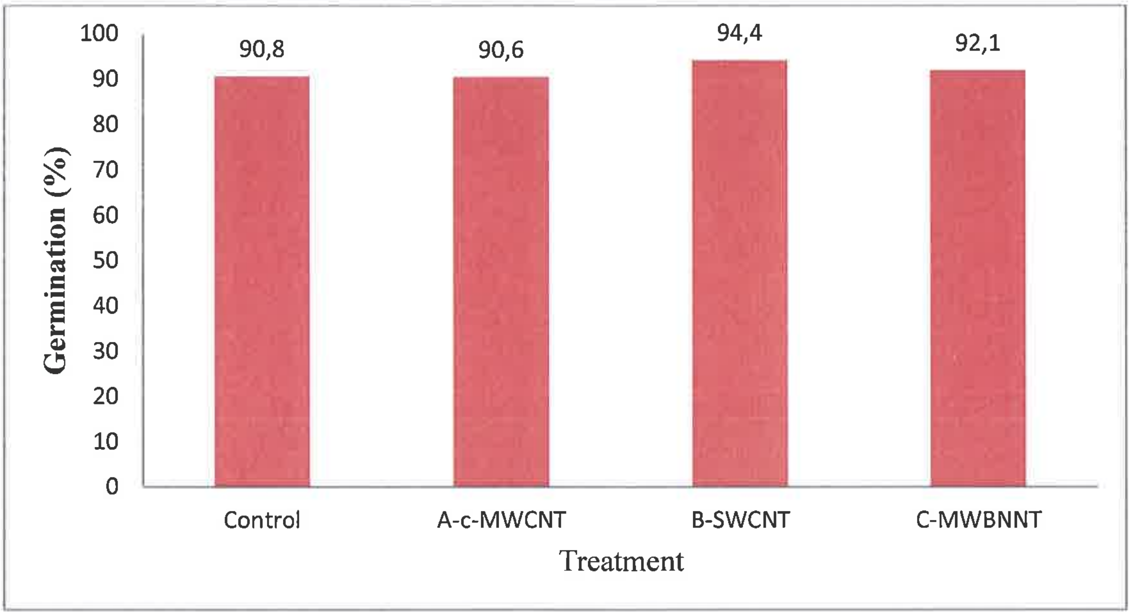


Figure 4.5. Effect of different nanoparticles on germination rates of wheat (Krasunia Odeska).

Table 4.3. Effect of different nanoparticles on number of wheat root following to germination.

Treatment*	Day**			
	2	3	4	5
A-Control	3,24±0,17 a B	3,48±0,15 a AB	3,69±0,15 a A	3,77±0,14 b A
B-c-MWCNT	3,04±,0,05 ab B	3,33±0,09 ab AB	3,59±0,13 a A	3,80±0,17 b A
C-SWCNT	3,00±0,00 b B	3,09±0,06 b B	3,83±0,87 a A	3,82±0,16 b A
D-MWBNNT	3,00±0,00 b B	3,13±0,09 b B	3,95±0,18 a A	4,09±0,17 a A

*Different lowercase letters in the same column indicate significant differences between the means of control and different nanoparticle treatments during germination at $P \leq 0.05$ according to LSD test.
**Different uppercase letters in the following four rows indicate significant differences between the means of the following days of germination at $P \leq 0.05$ according to the LSD test.

Table 4.4. Effect of different nanoparticles on wheat maximum root length (mm) following to germination.

Treatment*	Day **			
	2	3	4	5
A-Control	37,7±2,42 a D	66,1±2,08 a C	78,2±3,36 b B	97,3±4,45 b A
B-c-MWCNT	42,5±1,83 a D	60,4±1,76 a C	82,1±3,11 b B	110,6±3,98 a A
C-SWCNT	41,5±1,72 a D	65,7±2,22 a C	89,0±2,62 a B	110,7±2,39 a A
D-MWBNNT	39,5±1,87 a D	60,8±3,54 a C	81,7±2,31 b B	102,2±4,26 ab A

*Different lowercase letters in the same column indicate significant differences between the means of control and different nanoparticle treatments during germination at $P \leq 0.05$ according to LSD test.
**Different uppercase letters in the following four rows indicate significant differences between the means of the following days of germination at $P \leq 0.05$ according to the LSD test.

Table 4.5. Effect of different nanoparticles on wheat shoot length (mm) following to germination.

Treatment*	Day**			
	2	3	4	5
A-Control	25,3±1,59 a D	33,9±1,16 a C	62,1±2,70 a B	77,4±3,75 b A
B-c-MWCNT	25,6±0,80 a D	32,7±1,07a C	61,5±2,25 a B	85,9±2,80 a A
C-SWCNT	25,2±1,17 a D	32,6±1,61 a C	58,4±2,30 a B	82,3±1,66 ab A
D-MWBNNT	25,5±0,56 a D	30,9±1,89 a C	62,5±3,29 a B	86,0±2,66 a A

*Different lowercase letters in the same column indicate significant differences between the means of control and different nanoparticle treatments during germination at $P \leq 0.05$ according to LSD test.
**Different uppercase letters in the following four rows indicate significant differences between the means of the following days of germination at $P \leq 0.05$ according to the LSD test.

4.3. ROOT LENGTH, ROOT NUMBER AND SHOOT LENGTH RESULTS OF BARLEY SEED EXPERIMENT

The experiment includes 30 seeds for each day and below we showed the root lengths, root numbers and shoot lengths. In Tokak 157/37 barley type at the 5th day of germination compared with the control group the root lengths of carbon nanotubes were significantly increased compared with the control group. The SWCNT had the better root elongation with 120.36 mm and the second one is COOH-MWCNT with 101.52 mm length and also we detected a significant root elongation in MWBNNT 96.20 mm length application compared with the water control with 67,53 mm length. According to 5th day germination results, in the root numbers compared with the control groups the rooting number were closely same but we saw a little increase in carbon and boron nanotube applications compared with the control group ranked as SWCNT>MWBNNT>COOH-MWCNT >WATER CONTROL (. In shoot length of wheat the 5th day shooting results showed us these ranking as SWCNT >COOH-MWCNT> MWBNNT >WATER CONTROL. It shows us in barley SWCNT significantly increased the shooting and carbon nanotubes and boron nanotubes increased the shooting effects compared with the control group in barley (Table 4.6., Figure 4.6.).

Table 4.6. Root length, root number and shoot length of barley seed

	Root Length			
Treatment, day	**2**	**3**	**4**	**5**
A-Control	36,5	65,1	75,45	67,53
B-COOH-MWCNT	33,5	50,2	88,3	101,5
C-SWCNT	35,7	55,1	74,1	120,3
D-MWBNNT	42,6	44,9	77,7	96,2
	Root Number			
A-Control	4,7	4,4	4,3	4,2
B-COOH-MWCNT	4,8	4,3	4,5	4,4
C-SWCNT	3,4	4,1	4,5	4,7
D-MWBNNT	4,3	4,7	4,5	4,5
	Shoot Length			
A-Control	21,1	44,5	66,1	96,8
B-COOH-MWCNT	17,0	40,2	70,5	114,1
C-SWCNT	23,1	46,5	55,3	122,2
D-MWBNNT	14,05	61,8	66,6	110,1

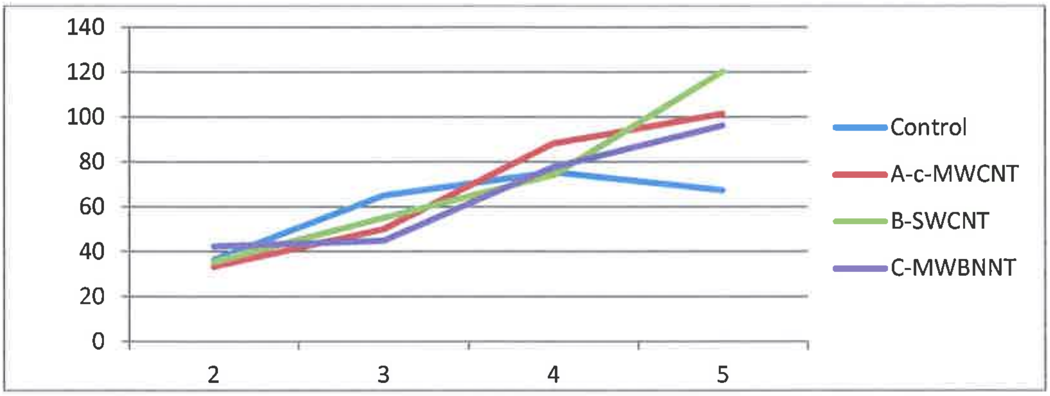


Figure 4.6. Effects of SWCNT, MWBNNT, and COOH-MWCT application on Tokak 157/37 barley type at the 5th day of germination compared with the control group

The root lengths of carbon nanotubes were significantly increased compared with the control group. The SWCNT had the better root elongation with 120.36 mm and the second one is COOH-MWCNT with 101.52 mm length and also we detected a significant root elongation in MWBNNT 96.20 mm length application compared with the water control with 67,53 mm length (Figure 4.7.).

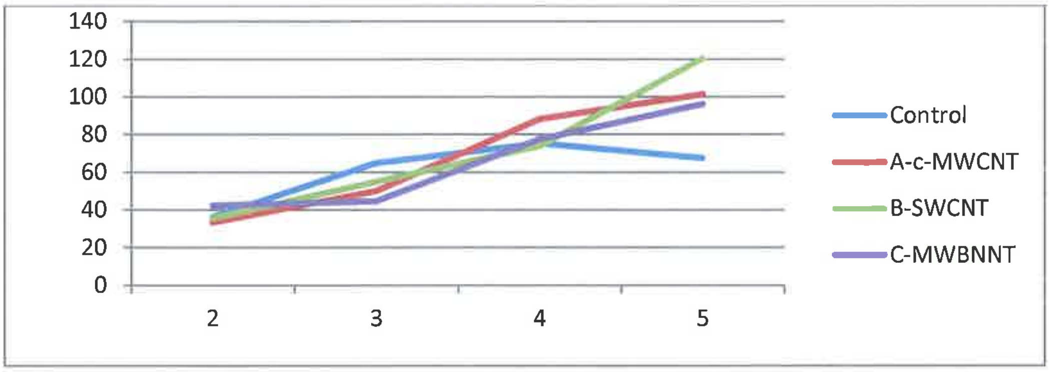


Figure 4.7. Effects of SWCNT, MWBNNT, and COOH-MWCT application on Tokak 157/37 barley type at the 5th day of root numbers compared with the control group

According to 5th day germination results, in the root numbers compared with the control groups the rooting number were closely same but we saw a little increase in carbon and boron nanotube applications compared with the control group ranked as SWCNT>MWBNNT>COOH-MWCNT >WATER CONTROL (Figure 4.8.).

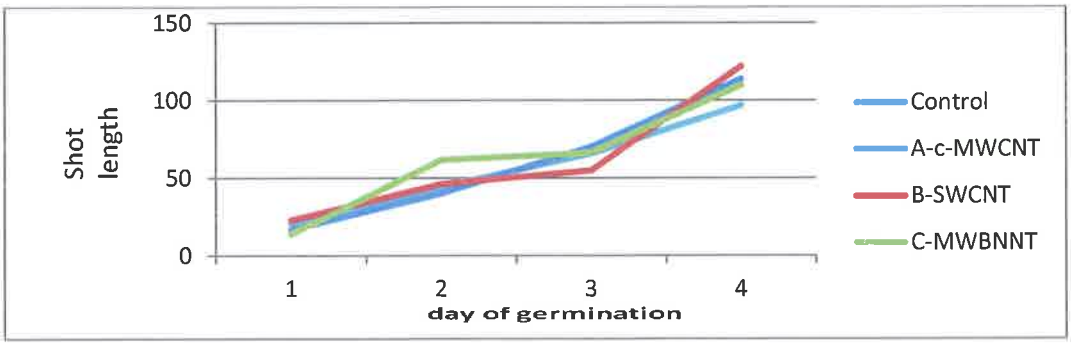


Figure 4.8. Effects of SWCNT, MWBNNT, and COOH-MWCT application on Tokak 157/37 barley type at the 5th day of shoot length compared with the control group

In shoot length of wheat the 5th day shooting results showed us these ranking as SWCNT >COOH-MWCNT> MWBNNT >WATER CONTROL. It shows us in barley SWCNT significantly increased the shooting and carbon nanotubes and boron nanotubes increased the shooting effects compared with the control group in barley (Figure 4.9. and Table 4.7., 4.8 and 4.9.).

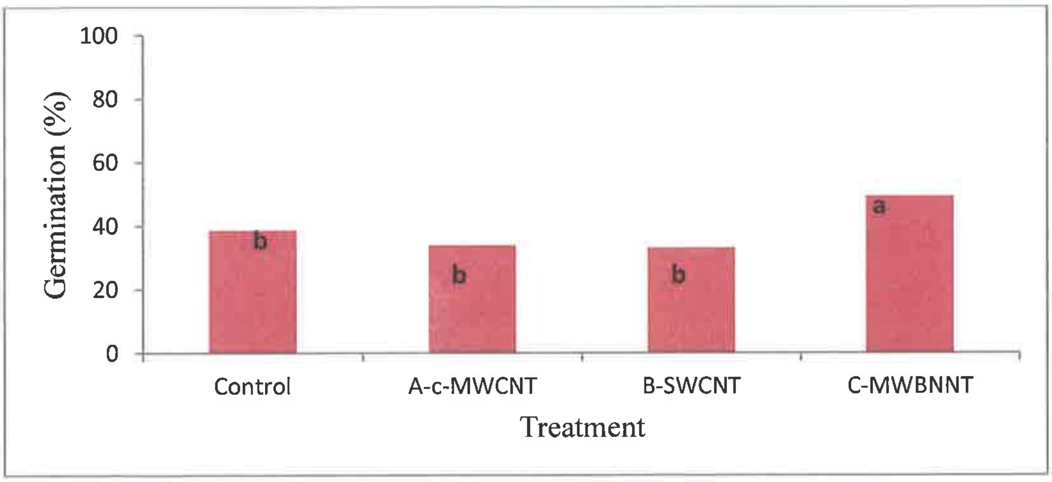


Figure 4.9. Effect of different nanoparticles on germination rates of barley.

Table 4.7. Effect of different nanoparticles on number of barley root following to germination.

Treatment*	Day**			
	2	3	4	5
A-Control	4,63±0,20 ab A	4,46±0,14 ab A	4,40±0,16 a A	4,70±0,21 a A
B-COOH-MWCNT	4,87±0,13 a A	4,38±0,18 b B	4,50±0,22a AB	7,43±2,89 a A
C-SWCNT	3,86±0,26 c B	4,38±0,26 ab A	4,45±0,21 a A	4,80±0,13 a A
D-MWBNNT	4,58±0,15 b A	4,75±0,18 a A	4,44±0,24 a A	4,55±0,17 a A

*Different lowercase letters in the same column indicate significant differences between the means of control and different nanoparticle treatments during germination at $P \leq 0.05$ according to LSD test.
**Different uppercase letters in the following four rows indicate significant differences between the means of the following days of germination at $P \leq 0.05$ according to the LSD test.

Table 4.8. Effect of different nanoparticles on barley maximum root length (mm) following to germination.

Treatment*	Day **			
	2	3	4	5
A-Control	38,5±2,74 b C	65,2±4,85 a B	82,0±5,88 a A	72,4±4,91 c AB
B-COOH-MWCNT	41,6±4,39 ab D	50,3±8,99 b C	88,30±4,31 a B	111,6±8,90 b A
C-SWCNT	42,4±3,15 ab D	60,5±4,60 ab C	79,3±8,98 a B	127,1±6,39 a A
D-MWBNNT	44,8±2,56 a D	61,8±4,37 ab C	84,1±13,4 a B	101,5±4,77 b A

*Different lowercase letters in the same column indicate significant differences between the means of control and different nanoparticle treatments during germination at $P \leq 0.05$ according to LSD test.
**Different uppercase letters in the following four rows indicate significant differences between the means of the following days of germination at $P \leq 0.05$ according to the LSD test.

Table 4.9. Effect of different nanoparticles on barley shoot length (mm) following to germination.

Treatment*	Day**			
	2	3	4	5
A-Control	19,4±2,29 a D	44,5±1,22 a C	66,1±8,45 a B	100,2±5,52 c A
B-COOH-MWCNT	18,7±3,36 a D	40,3±6,22 a C	70,5±8,00 a B	115,3±5,98 b A
C-SWCNT	23,1±2,32 a D	46,6±3,62 a C	56,3±6,23 a B	128,5±5,56 a A
D-MWBNNT	18,8±2,48 a D	44,9±2,69 a C	66,7±2,72 ab B	111,2±4,29 b A

*Different lowercase letters in the same column indicate significant differences between the means of control and different nanoparticle treatments during germination at $P \leq 0.05$ according to LSD test.
**Different uppercase letters in the following four rows indicate significant differences between the means of the following days of germination at $P \leq 0.05$ according to the LSD test.

4.4. WHEAT AND BARLEY ICP RESULTS FOR BORON

The 7th day dry shoot and root material were taken after a deep washing to measure accumulated boron amount in roots and shoots. We solved the dried materials in HNO_3 in 5% concentration, seperately. After preparing the homogenous solution, we buffered the samples on ICP. The ICP results are divided to total weight of shoots and roots (the germinated seeds percentage is calculated and average weight were calculated)and part per billion (ppb) based results of boron accumulation in shoots and roots are calculated (Table 4.10.).

Table 4.10. Wheat and Barley ICP Results for Boron. The average of three reading were taken from ICP results.The three reading data were given in the appendix (APPENDIX-1, APPENDIX-B, APPENDIX-C)

WHEAT	**B_2497**
COOH-MWCNT	
7th day dry	
root total(g)	ppb
0,1323	24845,0491
shoot total(g)	ppb

BARLEY	**B_2497**
COOH-MWCNT	
7th day dry	
root total(g)	ppb
0,0615	402,9268
shoot total(g)	ppb

0,26	11965,3846
SWCNT	
7th day dry	
root total(g)	ppb
0,1268	54408,5174
shoot total(g)	ppb
0,2373	19384,745
MWBNNT	
root total(g)	ppb
0,1096	187864,964
shoot total(g)	ppb
0,224	38647,3214
WATER	
root total(g)	ppb
0,1245	45534,1365
shoot total(g)	ppb
0,2316	100259,067

0,1391	35686,56
SWCNT	
7th day dry	
root total(g)	ppb
0,0685	56744,53
shoot total(g)	ppb
0,149	32798,66
MWBNNT	
root total(g)	ppb
0,0685	199708
shoot total	ppb
0,1445(g)	768,1661
WATER	
root total(g)	ppb
0,0779	46431,32
shoot total(g)	ppb
0,1765	33796,03

In MWBNNT's applicated wheat 7th day dry materials, compared with water control results, we found a distinct increase of boron in root content there was a clear decrease compared with water control group. In SWCNT applicated root content of wheat, we found a little increase of boron in root content compared with the control group but again in the shoot content there was a distinct decrease compared with water control group. In COOH-MWCNT applicated root content of wheat, we found a distinct decrease of boron in root content compared with the water control group and also there was a distinct decrease of boron in the shoot content compared with water control group.

In MWBNNT's applicated barley 7th day dry materials, compared with the water control results, we found a distinct increase of boron in root content, in the shoot content there was a distinct decrease compared with water control group. In SWCNT applicated root content of wheat, we found a little increase of boron in root content compared with the control group but again in the shoot content there was no distinct difference compared with water control group. In COOH-MWCNT applicated root content of barley, we found a distinct decrease of boron in root content compared with the water control group and in the shoot content also there was no distinct difference of boron in shoot content compared with water control group (4.. In an other study, phytotoxicity of five nanomaterials including MWCNTs have been tested and as a result it has been claimed the existence of MWCNTs significantly decreased biomass relative to controls or corresponding bulk materials and they have no effect on root clongation [24].

7th day germinated seeds dry weight of wheat (Krasunia Odeska) and germinated seed roots in 3 pots (including 10 seedlings in each pot) were used to measure the accumulation of boron with ICP method.

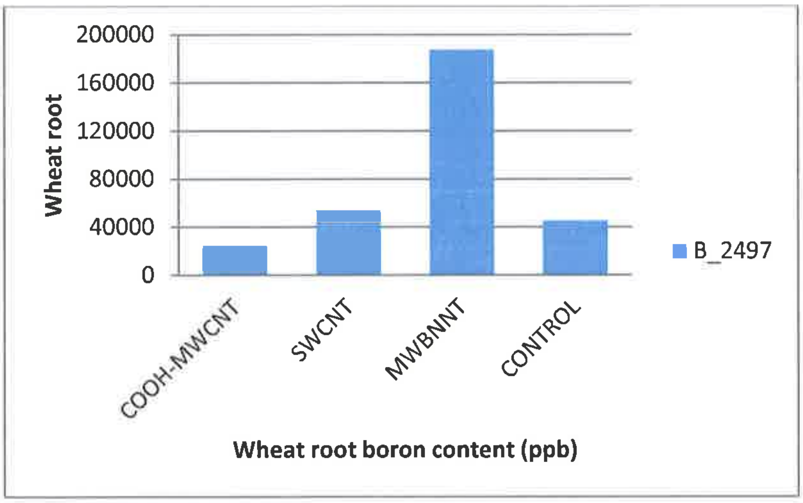


Figure 4.10. Effects of SWCNT, MWBNNT, and COOH-MWCT application on root B content of wheat (Krasunia Odeska)

The ICP readings were repeated 3 times and the results shown below were average of these 3 readings. These results measured as the scale of ppb (part per billion). The boron concentrations found in wheat roots as MWBNNT>SWCNT>CONTROL>COOH-MWCNT. It shows us the accumulation of boron in roots in the applicaton of MWBNNTs were significantly higher than the other groups (Figure 4.11.).

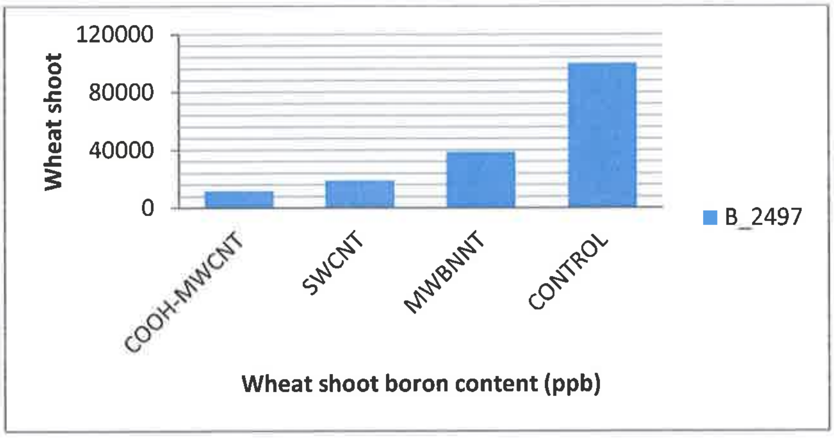


Figure 4.11. Effects of SWCNT, MWBNNT, and COOH-MWCT application on shoot B content of wheat (Krasunia Odeska)

7th day germinated seeds dry weight of wheat (Krasunia Odeska) and germinated seed shoots in 3 pots (including 10 seedlings in each pot) were used to measure the accumulation of boron with ICP method. The ICP readings were repeated 3 times and the results shown below were average of these 3 readings (Figure 4.12.). These results measured as the scale of ppb (part per billion). The boron concentrations found in wheat shoots as CONTROL>MWBNNT>SWCNT>COOH-MWCNT. It shows us the accumulation of boron in shoots were significantly higher in water control group compared with the other experiments.

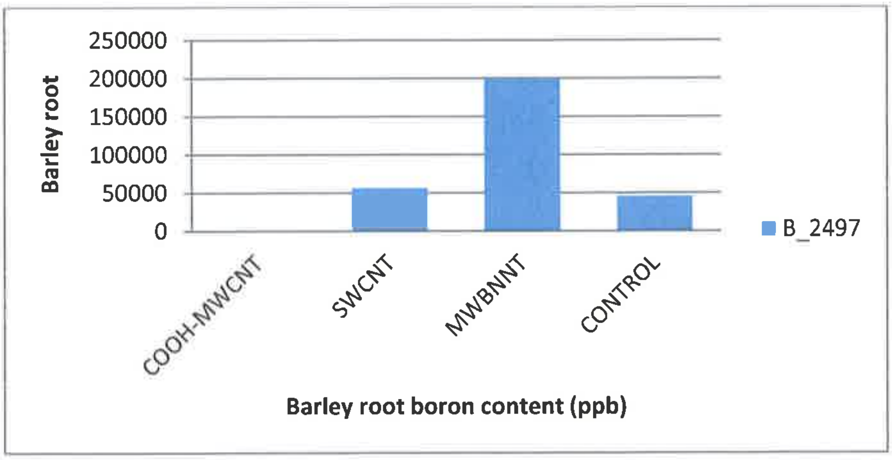


Figure 4.12. Effects of SWCNT, MWBNNT, and COOH-MWCT application on root B content of barley (Tokak 157/37)

7th day germinated seeds dry weight of barley (Tokak 157/37) and germinated seed roots in 3 pots (including 10 seedlings in each pot) were used to measure the accumulation of boron with ICP method. The ICP readings were repeated 3 times and the results shown below were average of these 3 readings. These results measured as the scale of ppb (part per billion). The boron concentrations found in barley roots as MWBNNT>SWCNT>CONTROL>COOH-MWCNT. It shows us the accumulation of boron in roots in the applicaton of MWBNNTs were significantly higher than the other groups (Figure 4.13.).

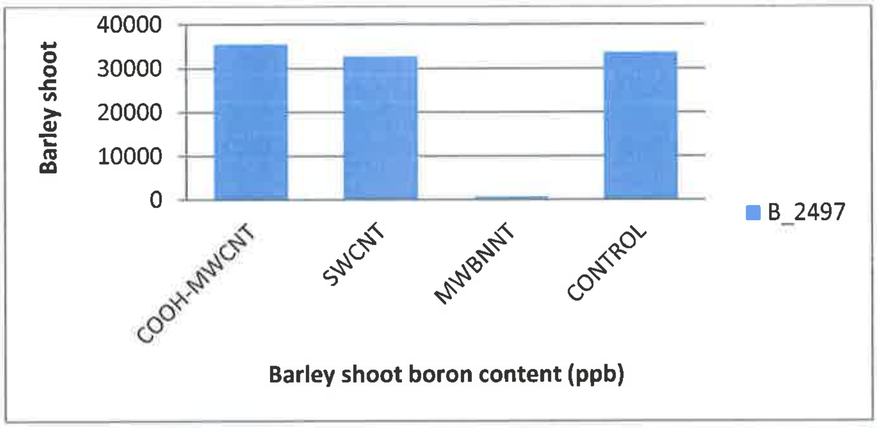


Figure 4.13. Effects of SWCNT, MWBNNT, and COOH-MWCT application on shoot B content of barley (Tokak 157/37)

7th day germinated seeds dry weight of barley (Tokak 157/37) and germinated seed shoots in 3 pots (including 10 seedlings in each pot) were used to measure the accumulation of boron with ICP method. The ICP readings were repeated 3 times and the results shown below were average of these 3 readings. These results measured as the scale of ppb (part per billion). The boron concentrations found in barley shoots as COOH-MWCNT > CONTROL >SWCNT> MWBNNT . It shows us the accumulation of boron in shoots in the applicaton of MWBNNTs were significantly less than compared with the other groups.

5. DISCUSSION

In this study we tested toxicity effect of SWCNTs, MWCNTs, MWBNNTs on wheat (Krasunia Odeska) (bread type wheat) and barley (Tokak 157/37) (malt type barley) seeds germination. In some previous studies, carbon nanotubes effects on germination were measured but the results were not matching and very different results were showed. In some of studies it was claimed that carbon nanotubes has positive effects on plant germination with root elongation of wheat and the effectivity of MWCNTs in root system pretends to improve activity of root dehydrogenase and leading a faster root growth and higher biomass production on wheat [22,23]. In an other study, phytotoxicity of five nanomaterials including MWCNTs have been tested and as a result it has been claimed the existence of MWCNTs significantly decreased biomass relative to controls or corresponding bulk materials and they have no effect on root elongation [24]. Since the literature has been poor background of nanotubes effects on plants and germination and also the existing results were not consistent we decided to compare the effects of nanotubes under the unique concentrations with the previous studies average to pretend the consistence and to proove if there is any toxicity effects of nanotubes exist on seed germination or not. This study has a crucial importance about to be the first study of measuring the boron nanotubes effects and toxicity on plant germination. In literature we couldn't find any study that measuring boron nanotubes effects on plants but there was many studies about boron nanotubes effects on animal or human cells and boron nanotubes effects were showed that boron nanotubes were noncytotoxic and can be functionalized for interaction with proteins and cells. Boron nanotubes have better qualifications and commercially cheaper than carbon nanotubes because of that in this study also we wanted to understand if boron nanotubes could be used instead of carbon nanotubes as an alternative source. In a study it was used 1000 mg/ L concentration to measure the toxicity effects and we found this concentration so high and even in this concentration to find a toxicity effect of nanotubes were expected result but in a lower and avearge concentration to detect the toxicity effect were important for the health of a study Table 5.1. and Figure 5.1.

Table 5.1. Effects of SWCNT, MWBNNT, and COOH-MWCT application on the germination days of Wheat (Krasunia Odeska) (bread type wheat) .

wheat germination days	Control	SWCNT	COOH-MWCNT	BNNT
Day 2	25	30	27	29
Day 3	28	26	26	29
Day 4	28	29	29	28
Day 5	29	29	28	27
Average of days	27,5	28,5	27,5	28,25
seeds	30	30	30	30
% average of days	92%	95%	92%	94%

Therefore, we used 80 mg/L concentration for all nanotube types to understand in the low boron and carbon nanotube concentration if there is any toxicity effect on plant germination. In the study, we used barley and wheat seeds because of these crops have crucial importance in human life and commercially important. We looked the germination rate, root and shoot length of germinated seeds and biomass of roots and shoots and with the ICP method we looked the accumulaton of boron in shoots and roots on wheat (Krasunia Odeska) (bread type wheat) and barley (Tokak 157/37) (malt type barley) species. According to results we didn't see any toxic effects of nanotubes of seed germination.

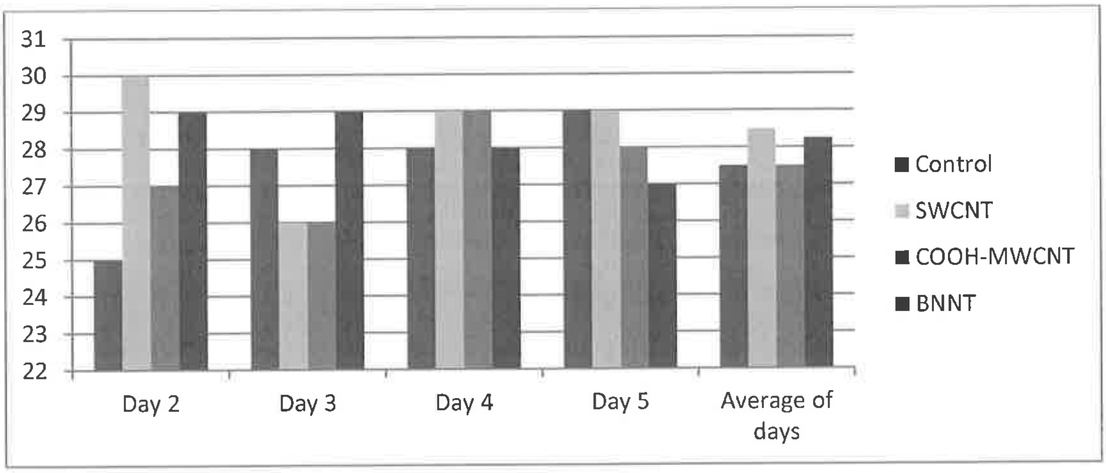


Figure 5.1. Effects of SWCNT, MWBNNT, and COOH-MWCT application on the germination numbers of Wheat (Krasunia Odeska) (bread type wheat).

While calculating the germination rate we took 2nd, 3th, 4th, 5th germination dates and for each day 10 seedlings 3 pots and totally the germination percentage was calculated on 120 seeds for each type of applications. As shown in the table in BNNTs we saw a little increase at SWCNT and MWBNNT but there was no significant difference on germination of nanotubes compared with the control groups (Figure 5.2).

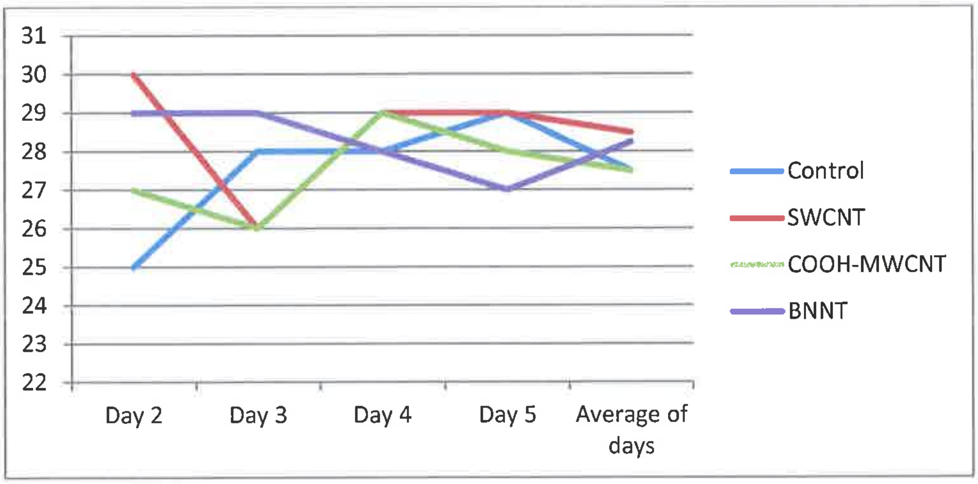


Figure 5.2. Effects of SWCNT, MWBNNT, and COOH-MWCT application on the germination numbers of Wheat (Krasunia Odeska) (bread type wheat).

While calculating the germination rate we took 2nd, 3th, 4th, 5th germination dates and for each day 10 seedlings 3 pots and totally the germination percentage was calculated on 120 seeds for each type of applications. As shown in the table in BNNTs we saw a little increase at SWCNT and MWBNNT but there was no significant difference on germination of nanotubes compared with the control groups.

While calculating the germination rate we took 2nd, 3th, 4th, 5th germination dates and for each day 10 seedlings 3 pots and totally the germination percentage was calculated on 120 seeds for each type of applications. As shown in the table in BNNTs we saw a significant increase at MWBNNT compared with the control group but there was a little decrease on barley germination of carbon nanotubes applications compared with the control group. Specially on the 5th day we had a significant germination rate increase compared with the other groups (Table 5.2 and Figure 5.3).

Table 5.2. Effects of SWCNT, MWBNNT, and COOH-MWCT application on the germination numbers of Barley (Tokak 157/37).

barley germination days	Control	SWCNT	COOH-MWCNT	BNNT
Day 2	11	7	8	10
Day 3	13	8	8	12
Day 4	10	11	10	9
Day 5	12	10	14	22
Average of days	11,5	9	10	13,25
seeds	30	30	30	30
% average of days	38%	30%	33%	44%

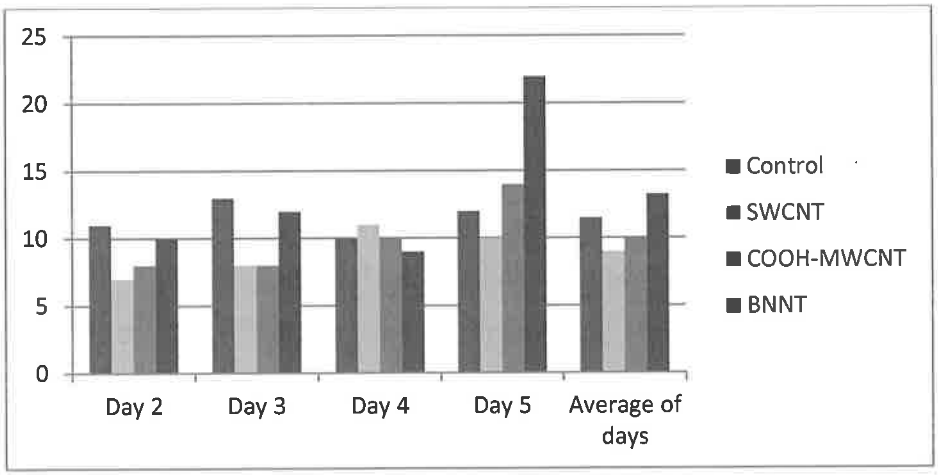


Figure 5.3. Effects of SWCNT, MWBNNT, and COOH-MWCT application on germination numbers of Barley (Tokak 157/37).

While calculating the germination rate we took 2nd, 3th, 4th, 5th germination dates and for each day 10 seedlings 3 pots and totally the germination percentage was calculated on 120 seeds for each type of applications. As shown in the table in BNNTs we saw a significant increase at MWBNNT compared with the control group but there was a little decrease on barley germination of carbon nanotubes applications compared with the control group. Specially on the 5th day we had a significant germination rate increase compared with the other groups (Figure 5.4.).

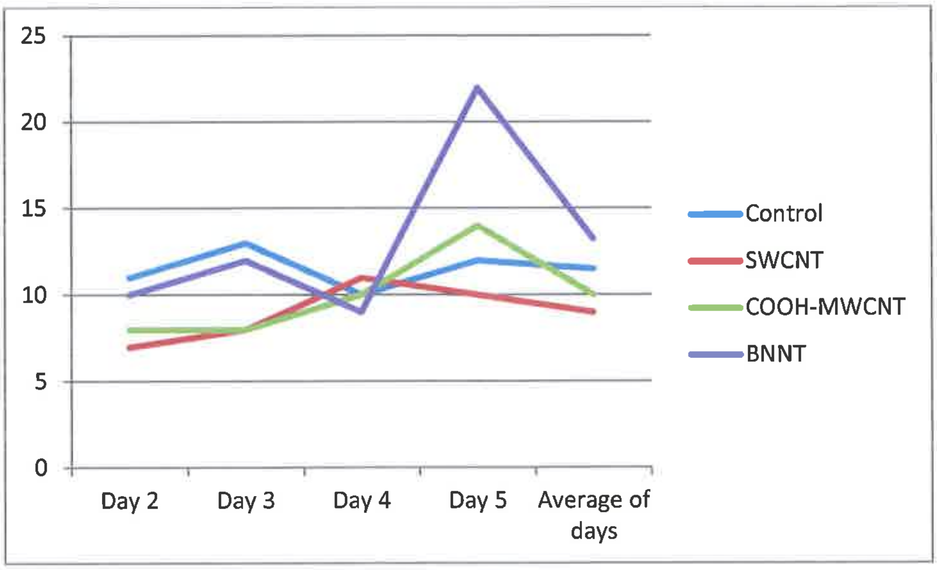


Figure 5.4. Effects of SWCNT, MWBNNT, and COOH-MWCT application on germination numbers of Barley (Tokak 157/37).

While calculating the germination rate we took 2nd, 3th, 4th, 5th germination dates and for each day 10 seedlings 3 pots and totally the germination percentage was calculated on 120 seeds for each type of applications. As shown in the table in BNNTs we saw a significant increase at MWBNNT compared with the control group but there was a little decrease on barley germination of carbon nanotubes applications compared with the control group. Specially on the 5th day we had a significant germination rate increase compared with the other groups.

6. CONCLUSION / FUTURE DIRECTIONS

As a conclusion we found no adverse effects of MWCNTs and SWCNTs on plant germination. In the study the germination experiment was done with whatman papers in pots method as in the previous studies. In the future the experiment can be repeated with agar method for a better dispersion of nanotubes. It was the first study of boron nanotubes effects on plant germination and we applied with two common crop species as wheat and barley. In further studies the other plants should be tested as different kind of crops and vegetebles etc. In the study we have done ICP tests to see the accumulation of boron but the results didn't make sense and unmeaningful. In further studies the ICP tests should be done and together with cDNA and ramon spectrometer tests should be done to see the cell growth and effect of boron nanotubes. In the future studies microscopy and micro array works should be done to understand the location and formation of boron nanotubes in plant roots and shoots.

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APPENDIX A: BORON NANOTUBES MEASURING REPORTS FIRST REPEAT

Horizontal	**Table**	**Report**								
Published:	11.10.2013	18:29:23								
Report	Author:									
Notes:										
						B_1826	B_2088	B_2089	B_2496	B_2497
11.10.2013	16:50:49	Blank			AS_Bor_0410	7.241	7.532	16.47	18.96	40.83
11.10.2013	16:53:08	CalibStd-1			AS_Bor_0410	9.644	9.877	20.72	22.39	49.42
11.10.2013	16:55:29	CalibStd-2			AS_Bor_0410	35.00	30.29	66.83	96.16	205.4
11.10.2013	16:57:49	CalibStd-3			AS_Bor_0410	148.8	125.2	275.1	429.0	901.0
11.10.2013	17:00:10	CalibStd-4			AS_Bor_0410	1429.	1185.	2592.	4091.	8623.
11.10.2013	17:02:24	Sample-1			AS_Bor_0410	1046.	1049.	1046.	1029.	1040.
11.10.2013	17:04:52	Sample-2			AS_Bor_0410	-.4543	-1.097	-1.719	-1.216	-.7483
11.10.2013	17:07:22	TOM	MWCNT	ROOT	AS_Bor_0410	-5.350	10.40	9.588	9.031	9.460
11.10.2013	17:09:53	Ba	MWBNNT	SHOOT	AS_Bor_0410	-159.5	110.7	110.0	108.5	111.0
11.10.2013	17:12:22	BA	MWCNT	ROOT	AS_Bor_0410	-94.39	25.37	24.56	23.70	24.78
11.10.2013	17:14:52	TOM	MWBNNT	SHOOT	AS_Bor_0410	-27.55	31.40	31.38	29.97	31.48
11.10.2013	17:17:24	TOM	MWBNNT	ROOT	AS_Bor_0410	-6.241	9.809	9.632	9.111	9.703
11.10.2013	17:19:55	TOM	MWCNT	SHOOT	AS_Bor_0410	-15.01	21.39	20.97	19.95	20.72
11.10.2013	17:22:27	TOM	SWCNT	ROOT	AS_Bor_0410	-2.143	8.542	14.83	7.303	8.244
11.10.2013	17:24:58	TOM	SWCNT	SHOOT	AS_Bor_0410	-240.0	168.9	213.1	156.4	170.6
11.10.2013	17:27:30	TOM	WATER	ROOT	AS_Bor_0410	-223.1	1569.	1580.	1509.	1568.
11.10.2013	17:30:02	TOM	WATER	SHOOT	AS_Bor_0410	-2531.	2603.	2567.	2459.	2564.
11.10.2013	17:32:34	BA	MWCNT	SHOOT	AS_Bor_0410	-21660.	4922.	4877.	4695.	4964.

11.10.2013	17:35:01	BA	MWBNNT	ROOT	AS_Bor_0410	1291.	13630.	13520.	13550.	13680.
11.10.2013	17:37:29	BA	SWCNT	ROOT	AS_Bor_0410	-9888.	3822.	8989.	3656.	3887.
11.10.2013	17:39:58	BA	SWCNT	SHOOT	AS_Bor_0410	-24070.	4780.	5679.	4612.	4887.
11.10.2013	17:42:28	BA	WATER	ROOT	AS_Bor_0410	-10050.	3646.	3582.	3419.	3617.
11.10.2013	17:44:57	BA	WATER	SHOOT	AS_Bor_0410	-28730.	5796.	5891.	5602.	5965.
11.10.2013	17:47:27	WH	MWBNNT	ROOT	AS_Bor_0410	5527.	20560.	20450.	20440.	20590.
11.10.2013	17:49:55	WH	MWBNNT	SHOOT	AS_Bor_0410	-20160.	8590.	8342.	8347.	8657.
11.10.2013	18:02:15	WH	MWCNT	ROOT1	AS_Bor_0410	-9466.	3273.	3239.	3139.	3287.
11.10.2013	18:06:28	WH	MWCNT	SHOOT2	AS_Bor_0410	-16880.	2952.	2853.	2804.	3111.
11.10.2013	18:09:18	WH	SWCNT	ROOT3	AS_Bor_0410	-14470.	6902.	13370.	6715.	6899.
11.10.2013	18:12:17	WH	SWCNT	SOOT4	AS_Bor_0410	-38740.	4463.	5218.	4237.	4600.
11.10.2013	18:15:18	WH	WATER	ROOT	AS_Bor_0410	-2553.	459.3	514.5	113.0	217.1
11.10.2013	18:17:31	WH	WATER	ROOT	AS_Bor_0410	-20990.	5580.	5474.	5329.	5669.
11.10.2013	18:20:15	WH	WATER	SHOOT	AS_Bor_0410	-9430.	22830.	22690.	22890.	23220.

Information about the ICP data results first readings.

APPENDIX B: BORON NANOTUBES MEASURING REPORTS SECOND REPEAT

Intensity	**Report**					
Published:	31.12.2014	16:03:38				
Report	Author:					
Notes:						
Blank						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	08.10.2013	11:05:16	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	83.19	Cts/S	30.670	36.868	83.19	
B_2088	84.67	Cts/S	28.899	34.132	84.67	
B_2089	211.7	Cts/S	52.990	25.035	211.66	
B_2496	277.9	Cts/S	120.101	43.220	277.89	
B_2497	590.6	Cts/S	249.667	42.274	590.59	
CalibStd-1						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	08.10.2013	11:07:38	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	75.22	Cts/S	14.787	19.657	75.22	
B_2088	75.38	Cts/S	18.139	24.065	75.38	
B_2089	189.6	Cts/S	29.107	15.353	189.59	
B_2496	245.2	Cts/S	0.8654	0.3530	245.16	
B_2497	520.5	Cts/S	35.728	0.6864	520.52	
CalibStd-2						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	08.10.2013	11:10:03	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	90.66	Cts/S	0.3293	0.3633	90.66	
B_2088	88.09	Cts/S	17.109	19.421	88.09	
B_2089	225.7	Cts/S	23.730	10.512	225.75	
B_2496	299.2	Cts/S	41.843	13.986	299.17	
B_2497	630.0	Cts/S	49.702	0.7890	629.96	
CalibStd-3						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	08.10.2013	11:12:23	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	190.9	Cts/S	21.720	11.378	190.89	
B_2088	184.4	Cts/S	0.8017	0.4348	184.39	

B_2089	462.2	Cts/S	55.898	12.095	462.15	
B_2496	628.2	Cts/S	176.120	28.034	628.23	
B_2497	1326.	Cts/S	392.093	29.575	1,325.75	
CalibStd-4						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	08.10.2013	11:14:42	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	1357.	Cts/S	273.304	20.146	1,356.59	
B_2088	1280.	Cts/S	196.950	15.387	1,279.97	
B_2089	3218.	Cts/S	562.512	17.478	3,218.41	
B_2496	4476.	Cts/S	2.362.376	52.773	4,476.49	
B_2497	9383.	Cts/S	4.658.079	49.646	9,382.58	
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Sample-1						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	08.10.2013	11:17:00	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-125.1	ppb	297.156	237.518	67.78	
B_2088	-171.7	ppb	269.817	157.119	64.92	
B_2089	-169.2	ppb	274.394	162.155	162.63	
B_2496	-139.6	ppb	655.629	469.652	221.38	
B_2497	-146.2	ppb	640.780	438.217	466.72	
Sample-2						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	08.10.2013	11:19:29	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-2411.	ppb	303.110	12.573	-213.49	
B_2088	174.4	ppb	231.813	132.906	104.70	
B_2089	235.0	ppb	159.620	67.923	279.69	
B_2496	207.1	ppb	324.111	156.472	361.61	
B_2497	224.4	ppb	285.941	127.414	780.44	
Blank						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	16:50:49	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	7.241	Cts/S	0.5056	69.830	Tem.24	
B_2088	7.532	Cts/S	0.7925	105.226	Tem.53	
B_2089	16.47	Cts/S	0.3255	19.766	16.47	
B_2496	18.96	Cts/S	28.280	149.149	18.96	
B_2497	40.83	Cts/S	55.039	134.812	40.83	

CalibStd-1						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	16:53:08	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	9.644	Cts/S	0.4221	43.767	Eyl.64	
B_2088	9.877	Cts/S	0.4016	40.656	Eyl.88	
B_2089	20.72	Cts/S	0.4288	20.692	20.72	
B_2496	22.39	Cts/S	27.990	125.037	22.39	
B_2497	49.42	Cts/S	21.882	44.280	49.42	
CalibStd-2						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	16:55:29	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	35.00	Cts/S	0.8023	22.925	35.00	
B_2088	30.29	Cts/S	0.8661	28.598	30.29	
B_2089	66.83	Cts/S	0.2013	0.3011	66.83	
B_2496	96.16	Cts/S	45.657	47.479	96.16	
B_2497	205.4	Cts/S	20.086	0.9779	205.40	
CalibStd-3						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	16:57:49	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
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CalibStd-3						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	16:57:49	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	148.8	Cts/S	13.129	0.8825	148.77	
B_2088	125.2	Cts/S	10.670	0.8524	125.18	
B_2089	275.1	Cts/S	16.694	0.6068	275.13	
B_2496	429.0	Cts/S	80.714	18.815	428.98	
B_2497	901.0	Cts/S	195.464	21.695	900.96	
CalibStd-4						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:00:10	Sample	Type:	Standard
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	1429.	Cts/S	86.084	0.6022	1,429.46	
B_2088	1185.	Cts/S	47.952	0.4046	1,185.09	
B_2089	2592.	Cts/S	131.084	0.5057	2,592.24	

B_2496	4091.	Cts/S	577.022	14.103	4,091.45	
B_2497	8623.	Cts/S	1.131.147	13.117	8,623.41	
Sample-1						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:02:24	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	1046.	ppb	127.443	12.185	155.83	
B_2088	1049.	ppb	77.757	0.7412	130.98	
B_2089	1046.	ppb	0.4966	0.0475	285.80	
B_2496	1029.	ppb	118.063	11.472	437.51	
B_2497	1040.	ppb	153.989	14.804	932.27	
Sample-2						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:04:52	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-.4543	ppb	0.0302	66.488	Haz.60	
B_2088	-1.097	ppb	0.5152	469.702	Haz.24	
B_2089	-1.719	ppb	0.0481	27.962	12.Nis	
B_2496	-1.216	ppb	0.6715	552.412	14.Oca	
B_2497	-.7483	ppb	0.5878	785.508	34.40	
TOM	MWCNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:07:22	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-5.350	ppb	0.1589	29.696	-0.36	
B_2088	Eki.40	ppb	0.3783	36.363	19.78	
B_2089	9.588	ppb	0.2099	21.894	41.15	
B_2496	9.031	ppb	0.2488	27.555	55.68	
B_2497	9.460	ppb	0.5547	58.636	121.89	
Ba	MWBNNT	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:09:53	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
Published:	31.12.2014	16:03:38	Page	3	of	9
Ba	MWBNNT	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:09:53	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-159.5	ppb	15.958	10.002	-219.41	

B_2088	110.7	ppb	12.685	11.457	137.82	
B_2089	110.0	ppb	10.119	0.9200	299.67	
B_2496	108.5	ppb	23.002	21.209	460.04	
B_2497	111.0	ppb	12.434	11.207	991.72	
BA	MWCNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:12:22	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-94.39	ppb	12.434	13.172	-126.85	
B_2088	25.37	ppb	0.5857	23.081	37.39	
B_2089	24.56	ppb	0.3805	15.496	79.70	
B_2496	23.70	ppb	0.5694	24.022	115.35	
B_2497	24.78	ppb	0.4411	17.798	253.21	
TOM	MWBNNT	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:14:52	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-27.55	ppb	0.3931	14.267	-31.90	
B_2088	31.40	ppb	0.1311	0.4176	44.48	
B_2089	31.38	ppb	0.8472	26.996	97.28	
B_2496	29.97	ppb	0.8784	29.309	140.85	
B_2497	31.48	ppb	0.8164	25.937	310.58	
TOM	MWBNNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:17:24	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-6.241	ppb	0.4776	76.531	-1.63	
B_2088	9.809	ppb	0.1142	11.641	19.Tem	
B_2089	9.632	ppb	0.3150	32.707	41.27	
B_2496	9.111	ppb	0.4555	49.991	56.01	
B_2497	9.703	ppb	0.0630	0.6495	123.98	
TOM	MWCNT	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:19:55	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-15.01	ppb	0.2798	18.640	-14.08	
B_2088	21.39	ppb	0.5875	27.470	32.70	
B_2089	20.97	ppb	0.6450	30.760	70.46	
B_2496	19.95	ppb	0.5274	26.441	100.08	
B_2497	20.72	ppb	0.0852	0.4111	218.41	

TOM	SWCNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:22:27	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
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TOM	SWCNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:22:27	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-2.143	ppb	0.1526	71.198	Nis.20	
B_2088	8.542	ppb	0.1438	16.829	17.58	
B_2089	14.83	ppb	0.5777	38.943	54.66	
B_2496	7.303	ppb	0.4727	64.730	48.66	
B_2497	8.244	ppb	0.2245	27.231	111.47	
TOM	SWCNT	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:24:58	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-240.0	ppb	18.926	0.7887	-26.85	
B_2088	168.9	ppb	105.754	62.604	27.41	
B_2089	213.1	ppb	43.071	20.215	71.33	
B_2496	156.4	ppb	65.446	41.840	82.57	
B_2497	170.6	ppb	44.753	26.234	187.02	
TOM	WATER	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:27:30	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-223.1	ppb	397.750	178.255	04.Tem	
B_2088	1569.	ppb	339.388	21.628	26.00	
B_2089	1580.	ppb	546.958	34.624	57.14	
B_2496	1509.	ppb	102.392	0.6786	80.32	
B_2497	1568.	ppb	57.559	0.3672	175.16	
TOM	WATER	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:30:02	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-2531.	ppb	429.127	16.952	-28.72	
B_2088	2603.	ppb	668.162	25.669	38.16	
B_2089	2567.	ppb	51.457	0.2005	82.56	

B_2496	2459.	ppb	745.576	30.320	118.96	
B_2497	2564.	ppb	52.844	0.2061	260.59	
BA	MWCNT	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:32:34	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-21660.	ppb	2.844.636	13.134	-300.44	
B_2088	4922.	ppb	579.820	11.781	65.45	
B_2089	4877.	ppb	323.891	0.6641	142.04	
B_2496	4695.	ppb	427.183	0.9099	209.89	
B_2497	4964.	ppb	803.638	16.188	466.28	
BA	MWBNNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:35:01	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
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BA	MWBNNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:35:01	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	1291.	ppb	1.024.442	79.371	25.58	
B_2088	13630.	ppb	849.307	0.6232	167.89	
B_2089	13520.	ppb	559.812	0.4141	364.59	
B_2496	13550.	ppb	1.309.692	0.9668	569.90	
B_2497	13680.	ppb	1.815.882	13.269	1,213.64	
BA	SWCNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:37:29	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-9888.	ppb	1.892.572	19.141	-133.22	
B_2088	3822.	ppb	593.931	15.540	52.51	
B_2089	8989.	ppb	1.281.905	14.260	247.93	
B_2496	3656.	ppb	804.329	22.000	167.64	
B_2497	3887.	ppb	828.876	21.323	373.96	
BA	SWCNT	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:39:58	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-24070.	ppb	3.506.715	14.569	-334.69	

B_2088	4780.	ppb	213.891	0.4475	63.78	
B_2089	5679.	ppb	191.507	0.3372	162.71	
B_2496	4612.	ppb	801.603	17.381	206.52	
B_2497	4887.	ppb	479.540	0.9813	459.64	
BA	WATER	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:42:28	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-10050.	ppb	2.132.782	21.220	-135.54	
B_2088	3646.	ppb	369.948	10.147	50.43	
B_2089	3582.	ppb	696.985	19.459	108.70	
B_2496	3419.	ppb	60.086	0.1757	158.02	
B_2497	3617.	ppb	736.694	20.369	350.79	
BA	WATER	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:44:57	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-28730.	ppb	3.974.031	13.834	-400.86	
B_2088	5796.	ppb	496.407	0.8565	75.73	
B_2089	5891.	ppb	480.547	0.8157	168.16	
B_2496	5602.	ppb	986.805	17.616	246.78	
B_2497	5965.	ppb	674.720	11.312	552.02	
WH	MWBNNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:47:27	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
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WH	MWBNNT	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:47:27	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	5527.	ppb	1.080.671	19.551	85.76	
B_2088	20560.	ppb	1.601.271	0.7788	249.47	
B_2089	20450.	ppb	2.855.463	13.965	542.95	
B_2496	20440.	ppb	2.951.779	14.443	850.14	
B_2497	20590.	ppb	3.256.189	15.817	1,805.21	
WH	MWBNNT	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:49:55	Sample	Type:	Unknown

Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-20160.	ppb	1.525.752	0.7567	-279.19	
B_2088	8590.	ppb	545.382	0.6349	108.61	
B_2089	8342.	ppb	184.657	0.2214	231.27	
B_2496	8347.	ppb	975.833	11.691	358.43	
B_2497	8657.	ppb	1.028.757	11.884	782.73	
20PPB						
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	17:59:07	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	19.96	ppb	0.5661	28.366	35.59	
B_2088	19.44	ppb	0.7976	41.026	30.41	
B_2089	20.18	ppb	0.1497	0.7419	68.43	
B_2496	19.34	ppb	0.1843	0.9527	97.63	
B_2497	19.Mar	ppb	0.3061	16.083	203.95	
WH	MWCNT	ROOT1				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:02:15	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-9466.	ppb	257.604	0.2722	-127.23	
B_2088	3273.	ppb	373.968	11.426	46.05	
B_2089	3239.	ppb	331.005	10.220	99.86	
B_2496	3139.	ppb	581.870	18.536	146.62	
B_2497	3287.	ppb	438.365	13.335	322.56	
WH	MWCNT	SHOOT2				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:06:28	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-16880.	ppb	2.745.022	16.266	-232.49	
B_2088	2952.	ppb	1.317.996	44.642	42.27	
B_2089	2853.	ppb	436.116	15.288	89.92	
B_2496	2804.	ppb	1.510.685	53.875	133.00	
B_2497	3111.	ppb	843.669	27.121	307.42	
WH	SWCNT	ROOT3				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:09:18	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
Published:	31.12.2014	16:03:38	Page	7	of	9
WH	SWCNT	ROOT3				
Method	Name:	AS_Bor_0410	Method	Revision:	1	

Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:09:18	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-14470.	ppb	1.170.991	0.8092	-198.33	
B_2088	6902.	ppb	765.995	11.099	88.75	
B_2089	13370.	ppb	2.367.858	17.716	360.63	
B_2496	6715.	ppb	1.458.158	21.716	292.04	
B_2497	6899.	ppb	1.938.149	28.094	632.06	
WH	SWCNT	SOOT4				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:12:17	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-38740.	ppb	3.595.993	0.9282	-543.11	
B_2088	4463.	ppb	56.785	0.1272	60.05	
B_2089	5218.	ppb	444.313	0.8515	150.82	
B_2496	4237.	ppb	629.937	14.868	191.27	
B_2497	4600.	ppb	229.543	0.4990	435.08	
WH	WATER	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:15:18	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-2553.	ppb	4,134.5700	1.619.591	-29.03	
B_2088	459.3	ppb	1,153.4534	2.511.251	Ara.94	
B_2089	514.5	ppb	1,061.5305	2.063.097	29.72	
B_2496	113.0	ppb	6.326.119	5.598.371	23.55	
B_2497	217.1	ppb	7.059.755	3.251.594	59.42	
WH	WATER	ROOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:17:31	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-20990.	ppb	1.256.574	0.5987	-290.91	
B_2088	5580.	ppb	1.056.568	18.933	73.20	
B_2089	5474.	ppb	385.040	0.7034	157.41	
B_2496	5329.	ppb	541.449	10.161	235.67	
B_2497	5669.	ppb	303.364	0.5352	526.63	
WH	WATER	SHOOT				
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:20:15	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-9430.	ppb	3.318.133	35.189	-126.72	

B_2088	22830.	ppb	2.590.442	11.345	276.21	
B_2089	22690.	ppb	2.319.303	10.222	600.67	
B_2496	22890.	ppb	4.252.433	18.580	949.80	
B_2497	23220.	ppb	4.636.289	19.967	2,030.82	
TNNT	ROT					
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:24:26	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
Published:	31.12.2014	16:03:38	Page	8	of	9
TNNT	ROT					
Method	Name:	AS_Bor_0410	Method	Revision:	1	
Analyst	Name:	sahin				
Acquire	Date:	11.10.2013	18:24:26	Sample	Type:	Unknown
Elem	Avg	Units	Stddev	%RSD	Intensity	Ratio
B_1826	-70.76	ppb	28.552	40.348	-1.14	
B_2088	122.6	ppb	13.387	10.919	19.55	
B_2089	122.8	ppb	46.121	37.571	42.81	
B_2496	114.2	ppb	39.940	34.971	57.66	
B_2497	121.2	ppb	14.668	12.102	127.38	
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Information about the ICP data results second readings.

APPENDIX C: BORON NANOTUBES MEASURING REPORTS THIRD REPEAT

Published:	31.12.2014	16:06:17						
Report	Author:							
Notes:								
Method	Name:	AS_Bor_0410	Revision:	1				
B_1826	MDL:	24,000.00000	Cts/S					
Measurement	Count:	41	DOF:	40	Confidence	Level:	98	SD:9,938
Sample	Name		Analyst Name	Acquisition	Date and Time	Avg	Stddev	%RSD
Blank			sahin	08.10.2013	11:05:16	83.19	30.670	3,6868
CalibStd-1			sahin	08.10.2013	11:07:38	75.22	14.787	1,9657
CalibStd-2			sahin	08.10.2013	11:10:03	90.66	0.3293	0,3633
CalibStd-3			sahin	08.10.2013	11:12:23	190.9	21.720	1,1378
CalibStd-4			sahin	08.10.2013	11:14:42	1357.	273.304	2,0146
Sample-1			sahin	08.10.2013	11:17:00	-125.1	297.156	23,7518
Sample-2			sahin	08.10.2013	11:19:29	-2411.	303.110	1,2573
Blank			sahin	11.10.2013	16:50:49	7.241	0.5056	6,983
CalibStd-1			sahin	11.10.2013	16:53:08	9.644	0.4221	4,3767
CalibStd-2			sahin	11.10.2013	16:55:29	35.00	0.8023	2,2925
CalibStd-3			sahin	11.10.2013	16:57:49	148.8	13.129	0,8825
CalibStd-4			sahin	11.10.2013	17:00:10	1429.	86.084	0,6022
Sample-1			sahin	11.10.2013	17:02:24	1046.	127.443	1,2185
Sample-2			sahin	11.10.2013	17:04:52	-.4543	0.0302	6,6488
TOM	MWCNT	ROOT	sahin	11.10.2013	17:07:22	-5.350	0.1589	2,9696

Ba	MWBNNT	SHOOT	sahin	11.10.2013	17:09:53	-159.5	15.958	1,0002
BA	MWCNT	ROOT	sahin	11.10.2013	17:12:22	-94.39	12.434	1,3172
TOM	MWBNNT	SHOOT	sahin	11.10.2013	17:14:52	-27.55	0.3931	1,4267
TOM	MWBNNT	ROOT	sahin	11.10.2013	17:17:24	-6.241	0.4776	7,6531
TOM	MWCNT	SHOOT	sahin	11.10.2013	17:19:55	-15.01	0.2798	1,864
TOM	SWCNT	ROOT	sahin	11.10.2013	17:22:27	-2.143	0.1526	7,1198
TOM	SWCNT	SHOOT	sahin	11.10.2013	17:24:58	-240.0	18.926	0,7887
TOM	WATER	ROOT	sahin	11.10.2013	17:27:30	-223.1	397.750	17,8255
TOM	WATER	SHOOT	sahin	11.10.2013	17:30:02	-2531.	429.127	1,6952
BA	MWCNT	SHOOT	sahin	11.10.2013	17:32:34	-21660.	2.844.636	1,3134
BA	MWBNNT	ROOT	sahin	11.10.2013	17:35:01	1291.	1.024.442	7,9371
BA	SWCNT	ROOT	sahin	11.10.2013	17:37:29	-9888.	1.892.572	1,9141
BA	SWCNT	SHOOT	sahin	11.10.2013	17:39:58	-24070.	3.506.715	1,4569
BA	WATER	ROOT	sahin	11.10.2013	17:42:28	-10050.	2.132.782	2,122
BA	WATER	SHOOT	sahin	11.10.2013	17:44:57	-28730.	3.974.031	1,3834
WH	MWBNNT	ROOT	sahin	11.10.2013	17:47:27	5527.	1.080.671	1,9551
WH	MWBNNT	SHOOT	sahin	11.10.2013	17:49:55	-20160.	1.525.752	0,7567
20PPB	sahin	11.10.2013	17:59:07	19.96	0.5661	2,8366		
WH	MWCNT	ROOT1	sahin	11.10.2013	18:02:15	-9466.	257.604	0,2722
WH	MWCNT	SHOOT2	sahin	11.10.2013	18:06:28	-16880.	2.745.022	1,6266
WH	SWCNT	ROOT3	sahin	11.10.2013	18:09:18	-14470.	1.170.991	0,8092
WH	SWCNT	SOOT4	sahin	11.10.2013	18:12:17	-38740.	3.595.993	0,9282
WH	WATER	ROOT	sahin	11.10.2013	18:15:18	-2553.	4,134.5700	161,9591
WH	WATER	ROOT	sahin	11.10.2013	18:17:31	-20990.	1.256.574	0,5987
WH	WATER	SHOOT	sahin	11.10.2013	18:20:15	-9430.	3.318.133	3,5189
TNNT	ROT	sahin	11.10.2013	18:24:26	-70.76	28.552	4,0348	
B_2088	MDL:	13,000.00000	Cts/S					

Measurement	Count:	41	DOF:	40	Confidence	Level:	98	SD:5,212
Sample	Name	Analyst	Name	Acquisition	Date	Avg	Stddev	%RSD
Blank	sahin	08.10.2013	11:05:16	84.67	28.899	3,4132		
CalibStd-1	sahin	08.10.2013	11:07:38	75.38	18.139	2,4065		
CalibStd-2	sahin	08.10.2013	11:10:03	88.09	17.109	1,9421		
CalibStd-3	sahin	08.10.2013	11:12:23	184.4	0.8017	0,4348		
CalibStd-4	sahin	08.10.2013	11:14:42	1280.	196.950	1,5387		
Sample-1	sahin	08.10.2013	11:17:00	-171.7	269.817	15,7119		
Sample-2	sahin	08.10.2013	11:19:29	174.4	231.813	13,2906		
Blank	sahin	11.10.2013	16:50:49	7.532	0.7925	10,5226		
CalibStd-1	sahin	11.10.2013	16:53:08	9.877	0.4016	4,0656		
CalibStd-2	sahin	11.10.2013	16:55:29	30.29	0.8661	2,8598		
CalibStd-3	sahin	11.10.2013	16:57:49	125.2	10.670	0,8524		
CalibStd-4	sahin	11.10.2013	17:00:10	1185.	47.952	0,4046		
Sample-1	sahin	11.10.2013	17:02:24	1049.	77.757	0,7412		
Sample-2	sahin	11.10.2013	17:04:52	-1.097	0.5152	46,9702		
TOM	MWCNT	ROOT	sahin	11.10.2013	17:07:22	Eki.40	0.3783	3,6363
Ba	MWBNNT	SHOOT	sahin	11.10.2013	17:09:53	110.7	12.685	1,1457
BA	MWCNT	ROOT	sahin	11.10.2013	17:12:22	25.37	0.5857	2,3081
TOM	MWBNNT	SHOOT	sahin	11.10.2013	17:14:52	31.40	0.1311	0,4176
TOM	MWBNNT	ROOT	sahin	11.10.2013	17:17:24	9.809	0.1142	1,1641
TOM	MWCNT	SHOOT	sahin	11.10.2013	17:19:55	21.39	0.5875	2,747
TOM	SWCNT	ROOT	sahin	11.10.2013	17:22:27	8.542	0.1438	1,6829
TOM	SWCNT	SHOOT	sahin	11.10.2013	17:24:58	168.9	105.754	6,2604
TOM	WATER	ROOT	sahin	11.10.2013	17:27:30	1569.	339.388	2,1628
TOM	WATER	SHOOT	sahin	11.10.2013	17:30:02	2603.	668.162	2,5669
BA	MWCNT	SHOOT	sahin	11.10.2013	17:32:34	4922.	579.820	1,1781

BA	MWBNNT	ROOT	sahin	11.10.2013	17:35:01	13630.	849.307	0,6232
BA	SWCNT	ROOT	sahin	11.10.2013	17:37:29	3822.	593.931	1,554
BA	SWCNT	SHOOT	sahin	11.10.2013	17:39:58	4780.	213.891	0,4475
BA	WATER	ROOT	sahin	11.10.2013	17:42:28	3646.	369.948	1,0147
BA	WATER	SHOOT	sahin	11.10.2013	17:44:57	5796.	496.407	0,8565
WH	MWBNNT	ROOT	sahin	11.10.2013	17:47:27	20560.	1.601.271	0,7788
WH	MWBNNT	SHOOT	sahin	11.10.2013	17:49:55	8590.	545.382	0,6349
20PPB	sahin	11.10.2013	17:59:07	19.44	0.7976	4,1026		
WH	MWCNT	ROOT1	sahin	11.10.2013	18:02:15	3273.	373.968	1,1426
WH	MWCNT	SHOOT2	sahin	11.10.2013	18:06:28	2952.	1.317.996	4,4642
WH	SWCNT	ROOT3	sahin	11.10.2013	18:09:18	6902.	765.995	1,1099
WH	SWCNT	SOOT4	sahin	11.10.2013	18:12:17	4463.	56.785	0,1272
WH	WATER	ROOT	sahin	11.10.2013	18:15:18	459.3	1,153.4534	251,1251
WH	WATER	ROOT	sahin	11.10.2013	18:17:31	5580.	1.056.568	1,8933
WH	WATER	SHOOT	sahin	11.10.2013	18:20:15	22830.	2.590.442	1,1345
TNNT	ROT	sahin	11.10.2013	18:24:26	122.6	13.387	1,0919	
B_2089	MDL:	13,000.00000	Cts/S					
Measurement	Count:	41	DOF:	40	Confidence	Level:	98	S.D.:5,452
Sample	Name	Analyst	Name	Acquisition	Date	Avg	Stddev	%RSD
Blank	sahin	08.10.2013	11:05:16	211.7	52.990	2,5035		
CalibStd-1	sahin	08.10.2013	11:07:38	189.6	29.107	1,5353		
CalibStd-2	sahin	08.10.2013	11:10:03	225.7	23.730	1,0512		
CalibStd-3	sahin	08.10.2013	11:12:23	462.2	55.898	1,2095		
CalibStd-4	sahin	08.10.2013	11:14:42	3218.	562.512	1,7478		
Sample-1	sahin	08.10.2013	11:17:00	-169.2	274.394	16,2155		
Sample-2	sahin	08.10.2013	11:19:29	235.0	159.620	6,7923		
Blank	sahin	11.10.2013	16:50:49	16.47	0.3255	1,9766		

CalibStd-1	sahin	11.10.2013	16:53:08	20.72	0.4288	2,0692		
CalibStd-2	sahin	11.10.2013	16:55:29	66.83	0.2013	0,3011		
CalibStd-3	sahin	11.10.2013	16:57:49	275.1	16.694	0,6068		
CalibStd-4	sahin	11.10.2013	17:00:10	2592.	131.084	0,5057		
Sample-1	sahin	11.10.2013	17:02:24	1046.	0.4966	0,0475		
Sample-2	sahin	11.10.2013	17:04:52	-1.719	0.0481	2,7962		
TOM	MWCNT	ROOT	sahin	11.10.2013	17:07:22	9.588	0.2099	2,1894
Ba	MWBNNT	SHOOT	sahin	11.10.2013	17:09:53	110.0	10.119	0,92
BA	MWCNT	ROOT	sahin	11.10.2013	17:12:22	24.56	0.3805	1,5496
TOM	MWBNNT	SHOOT	sahin	11.10.2013	17:14:52	31.38	0.8472	2,6996
TOM	MWBNNT	ROOT	sahin	11.10.2013	17:17:24	9.632	0.3150	3,2707
TOM	MWCNT	SHOOT	sahin	11.10.2013	17:19:55	20.97	0.6450	3,076
TOM	SWCNT	ROOT	sahin	11.10.2013	17:22:27	14.83	0.5777	3,8943
TOM	SWCNT	SHOOT	sahin	11.10.2013	17:24:58	213.1	43.071	2,0215
TOM	WATER	ROOT	sahin	11.10.2013	17:27:30	1580.	546.958	3,4624
TOM	WATER	SHOOT	sahin	11.10.2013	17:30:02	2567.	51.457	0,2005
BA	MWCNT	SHOOT	sahin	11.10.2013	17:32:34	4877.	323.891	0,6641
BA	MWBNNT	ROOT	sahin	11.10.2013	17:35:01	13520.	559.812	0,4141
BA	SWCNT	ROOT	sahin	11.10.2013	17:37:29	8989.	1.281.905	1,426
BA	SWCNT	SHOOT	sahin	11.10.2013	17:39:58	5679.	191.507	0,3372
BA	WATER	ROOT	sahin	11.10.2013	17:42:28	3582.	696.985	1,9459
BA	WATER	SHOOT	sahin	11.10.2013	17:44:57	5891.	480.547	0,8157
WH	MWBNNT	ROOT	sahin	11.10.2013	17:47:27	20450.	2.855.463	1,3965
WH	MWBNNT	SHOOT	sahin	11.10.2013	17:49:55	8342.	184.657	0,2214
20PPB	sahin	11.10.2013	17:59:07	20.18	0.1497	0,7419		
WH	MWCNT	ROOT1	sahin	11.10.2013	18:02:15	3239.	331.005	1,022
WH	MWCNT	SHOOT2	sahin	11.10.2013	18:06:28	2853.	436.116	1,5288

WH	SWCNT	ROOT3	sahin	11.10.2013	18:09:18	13370.	2.367.858	1,7716
WH	SWCNT	SOOT4	sahin	11.10.2013	18:12:17	5218.	444.313	0,8515
WH	WATER	ROOT	sahin	11.10.2013	18:15:18	514.5	1,061.5305	206,3097
WH	WATER	ROOT	sahin	11.10.2013	18:17:31	5474.	385.040	0,7034
WH	WATER	SHOOT	sahin	11.10.2013	18:20:15	22690.	2.319.303	1,0222
TNNT	ROT	sahin	11.10.2013	18:24:26	122.8	46.121	3,7571	
B_2496	MDL:	13,000.00000	Cts/S					
Measurement	Count:	41	DOF:	40	Confidence	Level:	98	S.D.:5,161
Sample	Name	Analyst	Name	Acquisition	Date	Avg	Stddev	%RSD
Blank	sahin	08.10.2013	11:05:16	277.9	120.101	4,322		
CalibStd-1	sahin	08.10.2013	11:07:38	245.2	0.8654	0,353		
CalibStd-2	sahin	08.10.2013	11:10:03	299.2	41.843	1,3986		
CalibStd-3	sahin	08.10.2013	11:12:23	628.2	176.120	2,8034		
CalibStd-4	sahin	08.10.2013	11:14:42	4476.	2.362.376	5,2773		
Sample-1	sahin	08.10.2013	11:17:00	-139.6	655.629	46,9652		
Sample-2	sahin	08.10.2013	11:19:29	207.1	324.111	15,6472		
Blank	sahin	11.10.2013	16:50:49	18.96	28.280	14,9149		
CalibStd-1	sahin	11.10.2013	16:53:08	22.39	27.990	12,5037		
CalibStd-2	sahin	11.10.2013	16:55:29	96.16	45.657	4,7479		
CalibStd-3	sahin	11.10.2013	16:57:49	429.0	80.714	1,8815		
CalibStd-4	sahin	11.10.2013	17:00:10	4091.	577.022	1,4103		
Sample-1	sahin	11.10.2013	17:02:24	1029.	118.063	1,1472		
Sample-2	sahin	11.10.2013	17:04:52	-1.216	0.6715	55,2412		
TOM	MWCNT	ROOT	sahin	11.10.2013	17:07:22	9.031	0.2488	2,7555
Ba	MWBNNT	SHOOT	sahin	11.10.2013	17:09:53	108.5	23.002	2,1209
BA	MWCNT	ROOT	sahin	11.10.2013	17:12:22	23.70	0.5694	2,4022
TOM	MWBNNT	SHOOT	sahin	11.10.2013	17:14:52	29.97	0.8784	2,9309

TOM	MWBNNT	ROOT	sahin	11.10.2013	17:17:24	9.111	0.4555	4,9991
TOM	MWCNT	SHOOT	sahin	11.10.2013	17:19:55	19.95	0.5274	2,6441
TOM	SWCNT	ROOT	sahin	11.10.2013	17:22:27	7.303	0.4727	6,473
TOM	SWCNT	SHOOT	sahin	11.10.2013	17:24:58	156.4	65.446	4,184
TOM	WATER	ROOT	sahin	11.10.2013	17:27:30	1509.	102.392	0,6786
TOM	WATER	SHOOT	sahin	11.10.2013	17:30:02	2459.	745.576	3,032
BA	MWCNT	SHOOT	sahin	11.10.2013	17:32:34	4695.	427.183	0,9099
BA	MWBNNT	ROOT	sahin	11.10.2013	17:35:01	13550.	1.309.692	0,9668
BA	SWCNT	ROOT	sahin	11.10.2013	17:37:29	3656.	804.329	2,2
BA	SWCNT	SHOOT	sahin	11.10.2013	17:39:58	4612.	801.603	1,7381
BA	WATER	ROOT	sahin	11.10.2013	17:42:28	3419.	60.086	0,1757
BA	WATER	SHOOT	sahin	11.10.2013	17:44:57	5602.	986.805	1,7616
WH	MWBNNT	ROOT	sahin	11.10.2013	17:47:27	20440.	2.951.779	1,4443
WH	MWBNNT	SHOOT	sahin	11.10.2013	17:49:55	8347.	975.833	1,1691
20PPB	sahin	11.10.2013	17:59:07	19.34	0.1843	0,9527		
WH	MWCNT	ROOT1	sahin	11.10.2013	18:02:15	3139.	581.870	1,8536
WH	MWCNT	SHOOT2	sahin	11.10.2013	18:06:28	2804.	1.510.685	5,3875
WH	SWCNT	ROOT3	sahin	11.10.2013	18:09:18	6715.	1.458.158	2,1716
WH	SWCNT	SOOT4	sahin	11.10.2013	18:12:17	4237.	629.937	1,4868
WH	WATER	ROOT	sahin	11.10.2013	18:15:18	113.0	6.326.119	559,8371
WH	WATER	ROOT	sahin	11.10.2013	18:17:31	5329.	541.449	1,0161
WH	WATER	SHOOT	sahin	11.10.2013	18:20:15	22890.	4.252.433	1,858
TNNT	ROT	sahin	11.10.2013	18:24:26	114.2	39.940	3,4971	
Published:	31.12.2014	16:06:17	Page	4	of	5		
B_2497	MDL:	13,000.00000	Cts/S					
Measurement	Count:	41	DOF:	40	Confidence	Level:	98	S.D.:5,358
Sample	Name	Analyst	Name	Acquisition	Date	Avg	Stddev	%RSD

Blank	sahin	08.10.2013	11:05:16	590.6	249.667	4,2274		
CalibStd-1	sahin	08.10.2013	11:07:38	520.5	35.728	0,6864		
CalibStd-2	sahin	08.10.2013	11:10:03	630.0	49.702	0,789		
CalibStd-3	sahin	08.10.2013	11:12:23	1326.	392.093	2,9575		
CalibStd-4	sahin	08.10.2013	11:14:42	9383.	4.658.079	4,9646		
Sample-1	sahin	08.10.2013	11:17:00	-146.2	640.780	43,8217		
Sample-2	sahin	08.10.2013	11:19:29	224.4	285.941	12,7414		
Blank	sahin	11.10.2013	16:50:49	40.83	55.039	13,4812		
CalibStd-1	sahin	11.10.2013	16:53:08	49.42	21.882	4,428		
CalibStd-2	sahin	11.10.2013	16:55:29	205.4	20.086	0,9779		
CalibStd-3	sahin	11.10.2013	16:57:49	901.0	195.464	2,1695		
CalibStd-4	sahin	11.10.2013	17:00:10	8623.	1.131.147	1,3117		
Sample-1	sahin	11.10.2013	17:02:24	1040.	153.989	1,4804		
Sample-2	sahin	11.10.2013	17:04:52	-.7483	0.5878	78,5508		
TOM	MWCNT	ROOT	sahin	11.10.2013	17:07:22	9.460	0.5547	5,8636
Ba	MWBNNT	SHOOT	sahin	11.10.2013	17:09:53	111.0	12.434	1,1207
BA	MWCNT	ROOT	sahin	11.10.2013	17:12:22	24.78	0.4411	1,7798
TOM	MWBNNT	SHOOT	sahin	11.10.2013	17:14:52	31.48	0.8164	2,5937
TOM	MWBNNT	ROOT	sahin	11.10.2013	17:17:24	9.703	0.0630	0,6495
TOM	MWCNT	SHOOT	sahin	11.10.2013	17:19:55	20.72	0.0852	0,4111
TOM	SWCNT	ROOT	sahin	11.10.2013	17:22:27	8.244	0.2245	2,7231
TOM	SWCNT	SHOOT	sahin	11.10.2013	17:24:58	170.6	44.753	2,6234
TOM	WATER	ROOT	sahin	11.10.2013	17:27:30	1568.	57.559	0,3672
TOM	WATER	SHOOT	sahin	11.10.2013	17:30:02	2564.	52.844	0,2061
BA	MWCNT	SHOOT	sahin	11.10.2013	17:32:34	4964.	803.638	1,6188
BA	MWBNNT	ROOT	sahin	11.10.2013	17:35:01	13680.	1.815.882	1,3269
BA	SWCNT	ROOT	sahin	11.10.2013	17:37:29	3887.	828.876	2,1323

BA	SWCNT	SHOOT	sahin	11.10.2013	17:39:58	4887.	479.540	0,9813
BA	WATER	ROOT	sahin	11.10.2013	17:42:28	3617.	736.694	2,0369
BA	WATER	SHOOT	sahin	11.10.2013	17:44:57	5965.	674.720	1,1312
WH	MWBNNT	ROOT	sahin	11.10.2013	17:47:27	20590.	3.256.189	1,5817
WH	MWBNNT	SHOOT	sahin	11.10.2013	17:49:55	8657.	1.028.757	1,1884
20PPB	sahin	11.10.2013	17:59:07	19.Mar	0.3061	1,6083		
WH	MWCNT	ROOT1	sahin	11.10.2013	18:02:15	3287.	438.365	1,3335
WH	MWCNT	SHOOT2	sahin	11.10.2013	18:06:28	3111.	843.669	2,7121
WH	SWCNT	ROOT3	sahin	11.10.2013	18:09:18	6899.	1.938.149	2,8094
WH	SWCNT	SOOT4	sahin	11.10.2013	18:12:17	4600.	229.543	0,499
WH	WATER	ROOT	sahin	11.10.2013	18:15:18	217.1	7.059.755	325,1594
WH	WATER	ROOT	sahin	11.10.2013	18:17:31	5669.	303.364	0,5352
WH	WATER	SHOOT	sahin	11.10.2013	18:20:15	23220.	4.636.289	1,9967
TNNT	ROT	sahin	11.10.2013	18:24:26	121.2	14.668	1,2102	

Information about the ICP data results third.