The impact of Argel and Haza plant shoots water extracts on seed germination and seedling growth of 'Kitchiner' mango cultivar

Abstract:

This study was conducted in the nursery of the College of Agricultural Studies (Shambat), Sudan University of Science and Technology, the objective with to investigate the impact of Argel and Haza plant shoots extracts on germination speed and percentage of seeds and seedling growth in 'Kitchiner' mango cultivar. Seeds were decorticated (Endocarp) and submersed in extracts under investigation for 90 minutes prior to planting in plastic bags containing a (2 silt: 1 sand mix) soil, under nursery conditions. The tested extracts were as follows: cold water extract of 15 g Argel plant shoots, hot water extract of 15 g Argel plant shoots, boiled water extract of 15 g Argel plant shoots, cold water extract of 15 g Haza plant shoots, hot water extract of 15 g Haza plant shoots and boiled water extract of 15 g Haza plant shoots beside the control. The complete randomized design was used and each treatment was replicated 10 times. Data were collected at 2 days interval. Germination started one week after planting. The results revealed an increase in germination percentage in treated seeds compared to the control. The highest germination percentage in the first reading was obtained from the cold water extract of Haza plant shoots and at the sixth reading 100% germination was achieved from the hot water extract of Haza plant shoots, while this percentage was recorded in the 8th week for the cold water extract of Argel plant hoots and in the 10th week for the hot water extract of Argel plant shoots. The highest germination percentage recorded for the control was only 60%. Significant increments in growth parameters were recorded as a result of treatments compared to the control. The boiled water extract of Haza plant shoots resulted in highest values for the

seedling height, number of embryos, root number and length and leaf width. The hot water Haza plant shoots extract recorded the highest values for seedling height (significantly similar to the boiled water extract of Haza plant shoots), stem thickness and leaf number. The hot water extract of Argel plant shoots did not differ significantly from the pre-stated results of the impact of hot and boiled water extracts of Haza plant shoots on seedling height, leaf number, length and width.

The results are indications of the efficacy of the tested plant extracts, especially hot and boiled water extracts of Haza plant shoots beside the boiled water extract of Argel plant shoots in increasing germination speed and percentage and growth attributes of the resulting seedlings in a way that may encourage further studies to confirm this growth promoting property and its use in other agricultural applications.

المستخلص العربى (Arabic Abstract)

اثر المستخلصات المائية لسيقان نبات الحرجل والحزى علي انبات البذور و نمو بادرات صنف المانجو (كتشنر)

أجريت هذه الدراسة بمشتل قسم البساتين, كلية الدراسات الزراعيه (شمبات)، جامعة السودان للعلوم والتكنولوجيا , بهدف دراسة أثر المستخلصات المائية لسيقان نبات الحرجل والحزى على سرعة ونسبة انبات البذور ونمو البادرات فى صنف المانجو كتشنر. تمت ازالة طبقه البذرة الخارجية المتخشبة (الأندوكارب) وغمرت البذور فى المستخلصات موضع الدراسة لمدة 90 دقيقة قبل الزراعة في اكياس بلاستك تحتوى مخلوط تربه (2طمي: 1 رمل) تحت ظروف المشتل. المستخلصات التى تم اختبارها كالآتى: مستخلص مائى بارد ل 15 جرام سيقان نبات الحرجل، مستخلص مائى ساخن ل 15 جرام سيقان نبات الحرجل، مستخلص مائى مغلى ل 15 جرام سيقان نبات الحرجل، مستخلص مائى بارد ل 15 جرام سيقان نبات الحزى، مستخلص مائى ساخن ل 15 جرام سيقان نبات الحزى، مستخلص مائى مغلى ل 15 جرام سيقان نبات الحزى، بجانب معاملة الشاهد. تم استخدام التصميم العشوائى الكامل وكررت كل معاملة 10 مرات. بدأ الانبات بعد أسبوع من الزراعة وجرى رصد قراءات الانبات كل يومين. اوضحت النتائج حدوث زيادة فى نسبة انبات البذور ناتجة عن المعاملات المختلفه مقارنة بالشاهد.

نتجت أعلى نسبة انبات عند القراءة الأولى من معاملة مستخلص مائى سيقان نبات الحزى البارد. وعند القراءة السادسة تم الحصول على انبات كامل (100%) من معاملة مستخلص مائي سيقان نبات الحزى الساحن. بينما تحققت هذه النسبة لمعاملة مستخلص مائى سيقان نبات الحرجل البارد عند القراءة الثامنة وعند القراءة العاشرة لمعاملة مستخلص سيقان نبات الحرجل الساخن ، أما أعلى نسبة انبات للشاهد فكانت 60% فقط.

رصدت زيادات معنوية ناتجة عن أثر المعاملات فى قياسات نمو البادرات مقارنة بالشاهد. معاملة مستخلص سيقان نبات الحزى المغلى نتج عنها أعلى مقاييس لعدد الأجنة وعدد وطول الجذور وعرض الورقة وارتفاع للبادرات، أما مستخلص سيقان نبات الحزى الساخن فقد نتج عنه أعلى ارتفاع للبادرات مساويا معنويا لأثر مستخلص مائي سيقان نبات الحزى المغلى وأكبر سمك للساق وأكبرعدد للأوراق. مستخلص مائي سيقان نبات الحرجل الساحن لم يختلف معنويا عما ذكر وحقق نتائج متساوية معنويا فى الزيادات التى تحققت فى ارتفاع البادرات وعدد الأوراق وطول وعرض الورقة. أشارت نتائج الدراسة بوضوح الى فعالية مستخلصات سيقان

النبـاتين المختبـرين خاصـة مسـتخلص مـائي سـقان نبـات الحـزى المغلـى أو السـاخن بجانـب مسـتخلص مـائي سـقان نبـات الحرجـل المغلـى فـى رفـع نسـبة وسـرعة الانبـات ومقـاييس نمـو البادرات بما يشجع على المزيد من الدراسات للتأكد من هذه الخاصية المحفزة للنمو واستحداماتها فى تطبيقات زراعية أخرى.

CHAPTER ONE

Introduction

Mango (*Mangifera indica* L.) is among the most important fruit crops of the tropics and subtropics. The mango belongs to the family Anacardiaceae and is a native of Southern Asia especially east India, Burma and the Andaman Islands, where it had been cultivated for more than 4000 years (Morton, 1987). It ranks third in the international tropical fruits trade. The mango is a widely consumed fresh fruit with worldwide production exceeding 35 million metric tons a year (FAO, 2009). The major producers of mango are: India, China, Thailand, Indonesia, Pakistan, Mexico, Brazil, Bangladesh, Nigeria and Philippines (FAO, 2014).

Mango is grown almost in all states of Sudan. The Main areas of Mango production extends along the main Nile banks in northern Sudan, and Blue Nile banks in central Sudan and also cultivated in some parts of southern Kordofan and in Darfur regions (HCENR, 2009, pp10) . The production season extends from February to September. Mango export comes on top of Sudanese horticultural crops, and mostly finds its way to Arab and European markets. Mango cultivars throughout the world had been derived from seeds. There are around 40 renounced cultivars in Sudan, but the majority of trees are of seedling origin. Accordingly, there are considerable chances for selection of elite genotypes from the vast seedling tree population. Scientific effort is badly needed for the assessment of chance elite seedling mango trees.

Mango is propagated by sexual and asexual means. Sexual propagation is needed for raising rootstocks and thereafter grafting of scions takes place to perpetuate the desired cultivars. The multiple seedlings that arise from one poly-embryonic seed resemble the mother tree except one that rises from the sexual embryo.   The seed of mango is coated by a hard shell that delays germination of embryos. Various approaches had been tried to enhance germination. Removal of seed coat was found best to speed germination (Gadalla 1993; Eltahir, and Abdalla, 1999).

Sudan is a vast country with diverse climatic zones and natural flora. This flora plays different roles such as pasture for grazing animals and to some extent a source for ethno-medicine. Recently, research trials proved the efficiency of some wild plant genotypes as growth promoters and bio-pesticides with a potential for agricultural uses. According to Idris *et al.*, (2012), addition of *Solenostemma argel* leaves to the soil was found enhancive to the yield and fruit physical qualities of date palm. They owed that to a growth regulator-like effect of argel. Besides, Eldoash *et al*. (2013), reported efficient control of the green pit scale insects in date palm upon foliar spray and soil treatment with Usher (*Calotropisprocera*) and Argel (*Solenostemma argel*). Such practices would add to efforts to replace chemicals in horticulture by natural products to avoid health hazards associated with synthetic chemicals in horticulture production. These results also provoke research interest in the different uses of herbs as tools for organic farming.

Objectives:

This study aimed to explore the effect of the cold, hot and boiled shoot extracts of Argel (*Solenostemma argel* Del. Haynes) and Haza (*Haplophyllum tuberculatum* Forsk.) on mango seed germination and growth attributes of the resulting seedlings.

CHAPTER TWO

Literature Review

2.1 The genus *Mangifera*:

Mangifera indica L., is a member of family Anacardiaceae which consists of about 73 genera and 850 species, most of which are in the tropics (Douthett, 2000). The most important are Anacardium (cashew nut genus) and Mangifera genera. The genus Mangifera consists of many species of Asian origin.

2.2 Origin and Distribution:

Mangifera indica is believed to have first appeared during the Quatenary period (Mukherjee, 1951). Blume (1850) considered that mango might have originated from several related species, primarily located in the Malay-archipelago.

The spread of mangoes outside their original centers of domestication probably did not occur until the beginning of the European colonialization of Asian countries in the 15th and 16thcenturies.

As mango seeds cannot survive for more than a few days or weeks, mango germplasm in the early days must have been transported as ripe fruits, seedlings or, later on, as grafted plants. The Portuguese and the Spaniards might have transported the mango from India and Philippines to their African and New World colonies (Knight and Schnell, 1993).

2.3 Botany:

Fully grown mango trees can reach a height of 40 m or more, and survive for several hundred years. The trees from openly pollinated seedling populations show variation in tree shape and size. The mango is a perennial, erect, branched evergreen tree. The bark is dark grey, brown to black, rather smooth but superficially cracked. The young leaves are produced in flushes and are pink to red or copper-colored and then turn into green. They remain on the tree for over a year. They are simple, alternate; with petioles that range in length from 7 to 12.5 cm. Leaf shape is highly variable, depending on the cultivar. Some can be lanceolate, oblong, ovate or intermediate involving these forms. Leaf length ranges from 12 to 40 cm and width between 5–13 cm. They are spirally arranged in whorls and are produced in flushes. The fruit is a one seeded drupe, composed of skin, fleshy edible portion and a stone enclosing a single seed (Litz, 2009). The seed contains one embryo (monoembryonic), or two or more embryos (polyembryonic) (Ruehle and Ledin, 1956). The canopy is normally oval, elongated or dome shaped. The juvenile phase of seedling trees ranges between 5 to 7 years. The root system is composed of a long, vigorous taproot and abundant surface lateral and tertiary roots (Litz, 2009).

Mango flowers are borne on terminal panicles, and are glabrous or pubescent; the inflorescence is generally an axiliary or terminal panicle. It is composed of perfect and male flowers. There is usually only one functional stamen and the others are reduced to abortive structures, called staminodes. The male flower lacks the ovary. The percentage of perfect flowers on a panicle ranges from 1.25 to 81.0%. Most of the perfect flowers are located in the apical zone of the panicle than in the basal and central portions (Ruehle and Ledin, 1956).The inflorescence is rigid and erect, up to 30 cm long, with secondary and tertiary branches. The inflorescence is usually densely flowered with hundreds of small flowers, which are 5–10 mm in diameter. The pistil aborts in male flowers. The ratio of male to perfect flowers is strongly influenced by environmental and cultural factors. The flowers have four or five sepals and petals. The floral disc also is four- or five-lobed, fleshy and large and located above the base of the petals. There are five large, fleshy stamens, only one or two of them are fertile; the remaining stamens are sterile staminodes that are surmounted by a small gland. In addition, two or three smaller filaments arise from the lobes of the nectaries. The stamens are central. The ovule is pendulous. It is believed that the flowers are cross-pollinated by flies. The fruit is a large, fleshy drupe, containing an edible mesocarp of varying thickness. The mesocarp is resinous and highly variable with respect to shape, size, color, presence of fiber and flavor. The flavor ranges from turpentine to sweet. The exocarp is thick and glandular. A sinus is always present above the beak. Fruit shape varies, including elongate, oblong and ovate or intermediate forms involving two of these shapes. Fruit length range from 5 to > 30 cm, depending on the cultivar. The endocarp is woody, thick and fibrous; the fibers in the mesocarp arise from the endocarp.

The mango fruit is climacteric, and increased ethylene production occurs during ripening. Chlorophyll, carotenes, anthocyanins and xanthophylls pigments are all present in the fruit. The skin is generally a mixture of green, red and yellow pigments, although fruit color at maturity is genotype dependent. During ripening the chloroplasts in the peel become chromoplasts which contain yellow and red pigments (Krishnamurthy and Subramanyam, 1970; Akamine and Goo, 1973; Salunkhe and Desai, 1984; Mitra and Baldwin, 1997). Peel color obviously is cultivar dependent (Lizada, 1991). The pulp carotenoids in ripe fruit also vary with respect to cultivar (Mitra and Baldwin, 1997). Flavor of the mango mesocarp is a function of carbohydrates, organic acids, lactase, monoterpene hydrocarbons and fatty acids (Mitra and Baldwin, 1997). During fruit maturation, starch content is hydrolyzed to sucrose, glucose and fructose (Medlicott *et al*., 1986; Selvaraj *et al*., 1989); sucrose is in slightly higher concentrations than either fructose or glucose. Organic acids content decreases during ripening (Krishnamurthy and Subramanyam, 1970). The dominant organic acid is citric acid, but glycolic acid, malic acid, tartaric acid and oxalic acids are also present (Sarker and Muhsi, 1981; Medlicott and Thompson,1985). The peach-like flavor of mangoes is attributed to the presence of lactones (Lakshminarayana, 1980; Wilson *et al*., 1990). Mango seeds are solitary, large and flat, ovoid oblong and surrounded by the fibrous endocarp at maturity. The testa and teguments are thin and papery. Embryos are dicotyledonous. Seeds of mono embryonic mango types contain a single zygotic embryo, whose cotyledons can be unequal in size or lobed in shape. The seeds of poly embryonic mango types contain one or more embryos; usually one embryo is zygotic, whereas the remaining embryos are asexual. Mangoes are an important component of the diet in many less developed countries in the subtropics and tropics.

Recent studies, however, have demonstrated that the poly embryony trait is inherited as a dominant character (Aron *et al*., 1998). Several studies have shown that nucellar seedlings can be distinguished from the single zygotic seedling of poly embryonic seeds by isozymes (Schnell and Knight, 1992; Degani *et al*., 1993) and DNA markers, for example single sequence repeats (SSRs),amplified fragment length polymorphisms (AFLPs) (Kashkush *et al*.,2001)(Utsunomiya 1999) and inter-simple-sequence-repeats (ISSRs) (Gonzalez *et al.*, 2002). Mango seeds are considered to be recalcitrant, and cannot survive for more than a few days or weeks at ambient temperatures (Parisot, 1988). This important characteristic of mango seeds would have inhibited the long distance dispersal of mango by seed until recent times. Mango seed rapidly loses viability if not properly stored; it is best sown fresh. Upon germination it forms a long tap root which may go down five meters in light soil but stop growth when it meets ground water. Seedling trees are known to live a long time over 100 years, while grafted trees may live for 80 years. The juvenile period of a seedling tree is three to seven years, but a grafted tree may start bearing in its second year. However, it is advisable to remove the bloom during the first four years, otherwise the tree will be greatly weakened (Singh, 1960). In the tropics flowers induction takes place during a dry period. If this last long enough for about four months then the flowers will appear in the same dry season. Otherwise, bloom may occur during the rains, which could prevent pollination and fruit setting. Pollination is mainly effected by flies, bees and thrips. It is rarely self-pollinated.

2.4Nutritional value:

Mango is recognized as one of the most popular fruits in the world market. It is valued for its excellent flavor, attractive fragrance, beautiful shades of color, delicious taste and healthful value (Nakasone & Paul, 1998). Mango fruit contains amino acids, carbohydrates, fatty acids, minerals, organic acids, proteins and vitamins. During the ripening process, the fruits are initially acidic, astringent and rich in ascorbic acid (vitamin C). Ripe mangoes contain moderate levels of vitamin C, but are fairly rich in pro-vitamin A, vitamin B1 and B2. The pulp contains vitamin A and an insignificant quantity of vitamin D. Fruit acidity is primarily due to the presence of malic and citric acids. In addition, oxalic, malonic, succinic, pyruvic, adipic, galacturonic, glucuronic, tartaric, glycolic and mucic acids are also present (Jain *et al.*, 1959; Fang, 1965). Acidity is cultivar related; for example, immature Florida cultivars have low acidity (0.5–1.0%) in comparison with ‘Alphonso’ (3%).

During ripening, acidity decreases to 0.1–0.2%. Following fruit set, starch accumulates in the mesocarp. Free sugars, including glucose, fructose and sucrose, generally increase during ripening; however, the sucrose content increases three- to fourfold due to the hydrolysis of starch. Sucrose is the principal sugar of ripe mangoes. The sucrose content of ripe fruits ranges from 11 to 20% representing 15 to 20% of the total soluble solids (Popenoe, 1932).

2.5 Environmental Requirements:

2.5.1 Soil:

The mango grows on a wide range of well-drained soils. In water logged areas, the tree may not die, but will remain unhealthy and chlorotic. Flat alluvial soils with pH 5.5-7 and a soil depth of at least 1 meter are preferred (Mostert and Abercombie, 1998). It can grow in 40 cm-deep soils in Florida, (Malo, 1972). 75 cm in South Africa (Mostert and Abercombie, 1998), or 80 cm in the Canary Islands (Galan Sauco, 2009). A hard layer in the soil profile can limit root penetration and needs to be broken by sub soiling. Exchangeable aluminium, which can be toxic, should be less than 30 ppm, and the tree is sensitive to saline condition. Mango is grown in very sandy soils, as well as in calcareous (>38% $caco_3$) with a pH close to 9 (Whiley and Schaffer, 1997).

2.5.2 Climate:

2.5.2.1 Temperature

As mango is a tropical fruit, the average maximum temperature should be between 27 and 36°C (Joubert and Bredell, 1982). The ideal for vegetative growth is between 25-27°C and around 36°C for flowering and fruit maturation (Galan Sauco, 2009). The lower limit for vegetative growth is 25°C (Whiley *et al*., 1988). Low temperature (<16 °C) leads to flower deformation, loss of pollen germination and slow pollen-tube growth and induce ovule abortion with the production of seedless fruit (Young and Sauls, 1979). It can endure up to 48°C during fruit development if sufficient irrigation is available, though at 40°C some leaf damage can occur. The damage minimum temperature is 1-2°C where the tree has no ability for acclimatization. Frost can severely damage or kill young trees, while older trees can endure (-4°C) for a few hours with limited damage (Crane and Campbell, 1991).

2.5.2.2 Elevation

Mango can be grown at elevation of 1200 m in the tropics, although the best production occurs at less than 800 m.

2.5.2.3 Light

The majority of mango cultivars develop better color under conditions of long days and more intensive sunlight (Snyman, 1992). Shading can prevent or delay flower-bud formation, and a higher percentage of perfect flowers occurs on the side of the tree receiving direct sun. Pruning can increase light penetration, more light may result in larger fruit and have a brighter skin color under higher light (Schaffer *et al*, 1994).

2.6 Propagation:

The two basic propagation options for mangoes are by seed or grafting. The best propagation method will depend on the cultivars required and the growing conditions. Mango seeds are either mono-embryonic (single embryo) or poly-embryonic (multiple embryos) depending on the variety. Poly-embryonic seeds produce true-to-type clones of the parent from the somatic embryos arising from the nucellar tissue and the single sexual embryo will differ from the parent plant. Most cultivars of mango are mono-embryonic and therefore they do not produce seedlings true-to-type. To obtain true to type transplants from mono-embryonic cultivars, it is necessary to use vegetative propagation means such as grafting. Grafted mango trees produce uniform growth, yield, fruit size and quality (Jauhari and Teaotia, 1972).

Mango seeds taken from ripe fruits do not show dormancy. They germinate at temperatures between 5 and 4O°C, but germination was most rapid near the upper end of this range (25-40°C). The fresh seed has high moisture content (85%) and quickly loses viability and dies if dehydrated. The optimal temperature for growth of the seedlings is close to 30°C. High temperatures (40°C) and temperatures below 15°C should be avoided. Growth of the stem occurs in successive flushes separated by rest periods. For breeding purposes, seeds are sometimes grown to produce new cultivars. Seeds are commonly used to produce rootstocks for improved cultivars. Polyembryonic cultivars of mango generally come true from seed, but monoembryonic types do not. Seedlings that do not come true often produce fruit that is small, poorly colored, with fibrous flesh and a resinous flavor.

Propagation by seed is only recommended for poly-embryonic mango varieties. Poly-embryonic seeds produce a number of shoots, one of which originates from fertilization. The fertilized seedling is often weak and stunted and should be discarded. The other seedlings are clones of the mother tree. However, any seed can be used to grow seedlings for grafting. The seedling will become the rootstock. Mango seeds lose viability very rapidly. It is essential to clean the seed as soon as possible after its removal from the fruit. It then needs to dry in the shade for a day or two. For enhanced germination, the outer husk must be removed before planting (Jauhari and Teaotia, 1972).

Seedlings are fairly easy to grow, but they may require 6 to 10 years or more to bear and the fruit may not be of desired quality unless the seedling originated from a cultivar which comes true from seed.

Mango is propagated vegetatively by grafting and layering; therefore, efficient rootstock is of utmost importance. Rootstocks play an important role in vegetative propagation of plants. It may modify form, adapt a variety or species to the soil, fit in an incompatible climate, impart or resist disease to the scion, increase production, hasten maturity of the crop, change color of the fruit, effect the flavor of the fruit, shorten life of the tree, increase the size of the fruit, develop vigor, affect salt tolerance and influence storage capacity (Jauhari and Teaotia, 1972). Therefore desired cultivars are propagated intact by budding, grafting, or other vegetative means. Budded or grafted mangos will usually begin to bear within 3 to 5 years of propagation. Veneer grafting and chip budding are the most common and successful methods of propagation of mangos in Florida, but other methods have been used. Propagation by cuttings and by air layering was successful in some areas of the tropic. In Sudan, approach grafting was the most used propagation method, but recently cleft and veneer grafting are more used (Ahmed, 2015).

2.7 Seed viability:

A viable seed is capable of germination under suitable conditions. The definition includes dormant but viable seeds, in which case the dormancy must be broken before viability can be measured by germination. A non-viable seed fails to germinate even under optimal condition, including treatments for the removal of dormancy. Factors affecting germination include the necessary amount of water, air and substrate temperature, composition of the seed bed, aeration, amount of contact between seed and moisture, seed temperature and illumination.

2.8 Rootstock:

The common practice in Sudan is the use of affordable unselected seed stones of which the term "Baladi" is coined as rootstock. Generally, 'Kitchener' is the cultivar to which all Baladi clones belong in Sudan and is the most widely used as a root-stock for mango propagation. In addition, no information is available about rootstock and scion combination (Elmardi and Elawad, 1984). However, Ahmed (2015) compared the effect of 'Kitchener' 'Miska' and 'Sabir' cultivars as root-stocks on performance of scion under Sudan condition , Sabir recorded the highest successful grafting followed by Miska and lowest was observed in Kitchener. The most common stocks, however, would be those of about 12 months old , about 40 to 50 cm long , 1 cm wide and about 20 to 30 cm above ground level. Field planted stocks are also favorable to be grafted after about 6 to 12 months growth, (DPI&F, 2005). The advantages of using rootstock in fruit propagation involve adaptation to soil and climatic condition; shortening the production period, improve quality of the fruit and indication of vigor in mango cultivar, (Kadman *et al*., 1978). A good rootstock must be uniform, grow vigorously, has tolerance to soil-borne diseases and induce regular bearing.

2.9 Mango in Sudan:

Mango cultivars had been introduced in the Sudan towards the end of the 18th century from Egypt. Mango cultivars in Sudan can be classified into three types according to the season of fruit maturity into early (baladi), intermediate (Alphonse, Zibdah), and late (Totapary and Abu-samaka). Generally most of the cultivars are characterized by one fruiting season (Elmardi& Elawad 1984). There are more than 30 commercial cultivars grown in different regions in the Sudan. Most areas under cultivation (more than 90%) are allotted for growing the local cultivar ‘Kitchener’ (Baladi). Other high quality commercial cultivars are grown in some regions of Sudan in limited areas, namely, Alphonso, Mulgoba, Zebda, Nylum, Abu Samaka, Tommy Atkins, Keitt and Kent. The most pressing problem in mango growing is alternate bearing (HSA,FMA 2009). Statistical data on area and production of mango in Sudan are compiled in appendix 1.

Chapter Three

Material and methods

Ripe mango fruits of uniform size were obtained from fifty-year-old trees of 'Kitchener' mango cultivar growing in the orchard belonging to the Federal Horticulture Sector Administration at Mogran, Khartoum, Sudan. Flesh was removed by a sharp knife and seeds were thoroughly washed with tap water. The seed coat (endocarp or husk) was removed with a hand pruner. The decorticated seeds were then employed as plant material for experimentation. Argel and Haza plant shoots water extracts were tested to determine their impacts on germination and seedling growth. The decorticated mango seeds received one of the following treatments:

1. Untreated control.
2. Immersion in cold water extract of 15 g Argel plant shoots/l.
3. Immersion in hot water extract of 15 g Argel plant shoots / l.
4. Immersion in boiled water extract of 15 g Argel plant shoots /l.
5. Immersion in Haza plant cold water shoots extract of 15 g/l.
6. Immersion in Haza plant hot water shoots extract of 15 g/l.
7. Immersion in Haza plant boiled water shoots extract of 15 g/l.

Each seed was planted separately in 20X25 cm polyethylene plastic bag containing a (2 silt: 1 sand mix) soil. The immersion time was 90 minutes prior to seed planting. Each seed in a plastic bag was considered a replicate and each treatment was composed of 7 replicates.

Data were collected for the following parameters: Germination %, seedling height (cm), number of leaves/seedling, leaf length (cm), leaf width (cm), number of embryos, stem diameter (cm) by a vernier caliper, number of roots and root length (cm). Data were subjected to analysis of variance for the complete randomized design. Means were separated by Duncan Multiple Range Tests with the aid of MStatC Computer program

Chapter Four

Results

Data on germination percentage were collected every 2 days starting one week after seed planting. According to Table (1) and Figure (1), the cold water extract of Haza plant shoots resulted in best germination for the first reading and shared the top rank in the second reading with the boiled water extract of Haza plant shoots that also ranked top in the third and fourth readings. From the fifth reading onward the hot water Haza plant shoots extract resulted in best germination reaching 100% germination in the sixth reading. 100% germination percentage was also achieved in the eighth reading for the cold water extract of Argel plant shoots, and in the tenth reading for the hot water extract of Argel plant shoots. From the 10^{th} reading onward, no change was observed in all treatments. At this reading the lowest percentage (60%) was recorded for the control, while 100% germination was recorded for the cold and hot extracts of Argel plant shoots and the hot water extract of Haza plant shoots.

Table (1): The effect Argel and Haza plant shoots extracts on speed and percentage of mango seed germination

Treatment	Read1	Read2	Read3	Read4	Rread5	Read6	Read7	Read8	Read9	Read10	Read11
Control	0	0	0	0	40	50	50	50	60	60	60
Cold Argel	10	10	10	30	50	60	90	100	100	100	100
Hot Argel	0	20	20	20	30	50	50	60	80	100	100
Boiled Argel	0	30	50	50	60	70	80	80	80	80	80
Cold Haza	40	40	40	50	50	90	90	90	90	90	90
Hot Haza	10	10	30	60	80	100	100	100	100	100	100
Boiled Haza	20	40	70	70	70	90	90	90	90	90	90

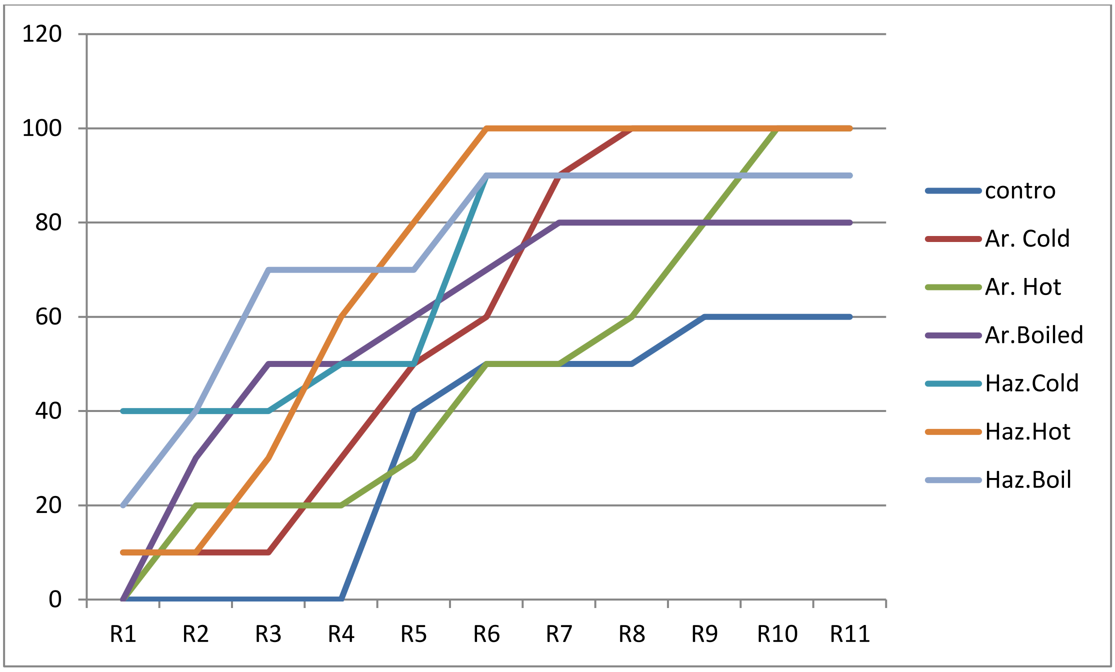


Fig.1. Effect of Argel and Haza plant shoots extracts on speed and percentage of mango seed germination.

X- axis: Reading number.

Y–axis: Germination percentage.

Results of seedling height, number of leaves per seedling, leaf length and width are illustrated in Table (2). The hot and boiled water Haza plant shoots extracts increased seedling height over all treatments except the hot water extract of Argel plant shoots. All extracts increased the number of leaves compared to the control. The hot water extract of Haza plant shoots ranked top for this parameter although it did not differ significantly from all extracts of Argel plant shoots. Regarding leaf length, the hot water extract of Argel plant shoots resulted in significant increase compared to all treatments, while the boiled extract of Haza plant shoots ranked second. The cold water extract of Haza plant shoots reduced the leaf length significantly compared to the control and the cold water extract of Argel plant shoots that shared the same level of significance. All extracts increased leaf width significantly in comparison to the control. The boiled water Haza plant shoots extract increased leaf width significantly over all treatments except the hot water extracts of Argel and Haza plant shoots.

Table 2. The effect of Argel and Haza plant shoots water extracts on seedling height, number of leaves, leaf length and width of 'Kitchener' mango cultivar

Treatments	Seedling height (cm)	Number of Leaves	Leaf length (cm)	Leaf width (cm)
Control	26.71c	7.71d	14.89d	4.343d
Cold Argel	26.11c	9.43ab	14.89d	5.29bc
Hot Argel	31.60ab	10.00ab	18.81a	5.61ab
Boiled Argel	29.27bc	9.57ab	16.46c	5.17bc
Cold Haza	26.07c	8.71c	14.00e	4.90c
Hot Haza	34.56a	10.14a	17.2bc	5.54ab
Boiled Haza	35.11a	9.29bc	17.76b	5.86a

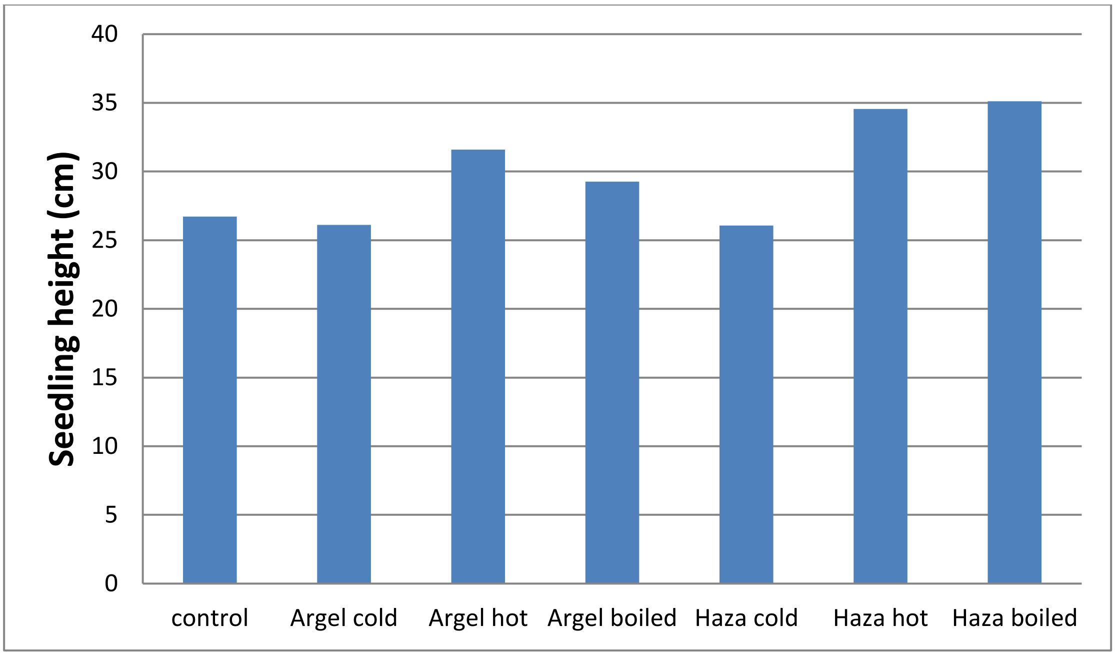
Means with the same letter(s) within a column are not significantly difference according to DMRT at 95% confidence limit.

The impact of the extracts applications on the number of embryos per seed, seedling stem diameter, number and length of roots is shown in Table (3). The boiled water Haza plant shoots extract increased the number of embryos significantly compared to other treatments except the cold and boiled water extracts of Argel plant shoots. Except the cold water extract of Haza plant shoots, all extracts increased the stem diameter significantly compared to the control. Seeds submersed in the hot water extract of Haza plant shoots ranked top for this parameter, but without significant difference from the hot and boiled water extracts of Argel plant shoots. All extracts increased the root length significantly in comparison to the control. The boiled water Haza plant shoots extract increased the root length significantly over all treatments. Regarding the number of roots per seedling, the boiled water extract of Haza plant shoots also resulted in significant increase compared to all treatments except the boiled water extract of Argel plant shoots, while the hot water extract of Argel plant shoots ranked second.

Table 3. The effect of Argel and Haza plant shoots water extracts on number of embryos, stem diameter, root length and number of roots of 'Kitchener' mango cultivar.

Treatments	**Number of embryos**	**Stem diameter (cm)**	**Root length (cm)**	**Number of Roots**
Control	2.14bc	3.73d	29.14f	23.86e
Cold Argel	2.43ab	4.21bc	32.79d	31.71d
Hot Argel	2.00bc	4.66ab	35.71c	36.57b
Boiled Argel	2.43ab	4.30abc	35.06c	37.29ab
Cold Haza	1.86c	3.83cd	31.90e	32.43d
Hot Haza	2.14bc	4.74a	37.90b	34.43c
Boiled Haza	2.86a	4.01cd	40.14a	37.71a

Means with the same letter(s) within a column are not significantly difference according to DMRT at 95% confidence limit.



Fige.2. Effect of Argel and Haza plant shoots water extracts treatments on seedling height of 'Kitchener' mango cultivar

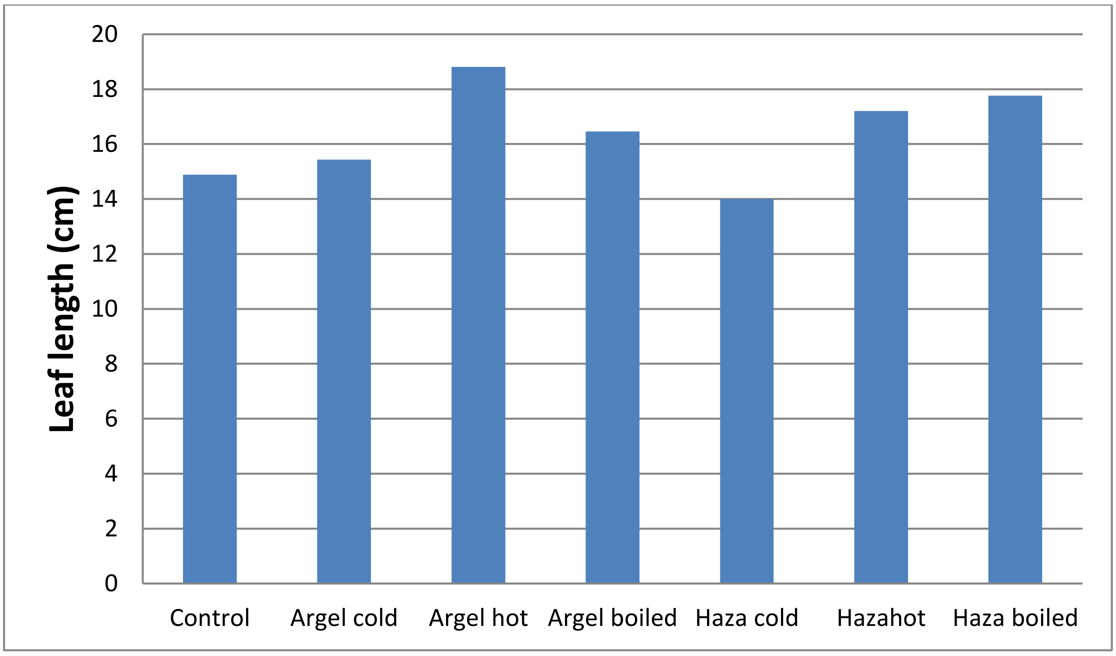


Fig.3. Effect of Argel and Haza plant shoots water extracts treatments on leaf length of 'Kitchener' mango cultivar

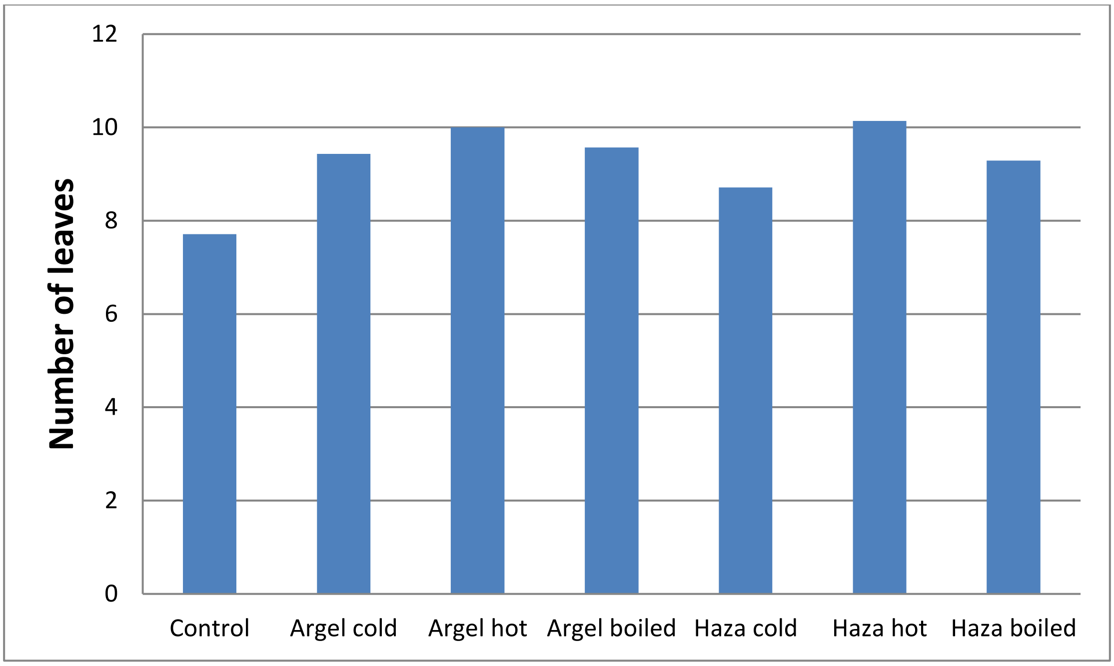


Fig.4. Effect of Argel and Haza plant shoots water extracts treatments on number of leaves of 'Kitchener' mango cultivar

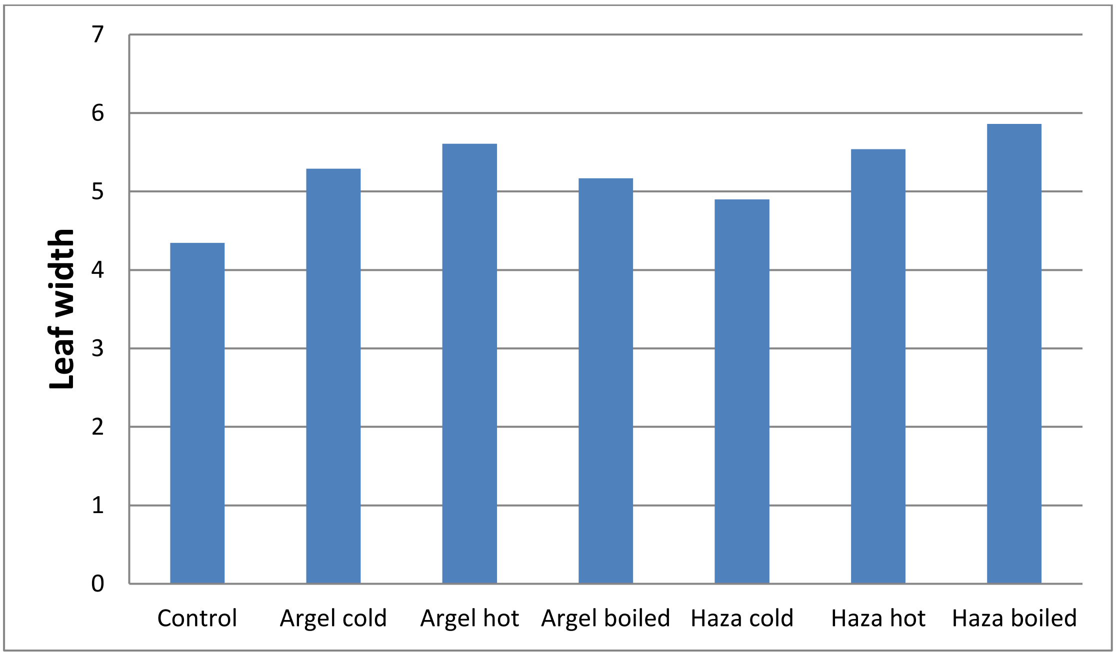


Fig.5. Effect of Argel and Haza plant shoots water extracts treatments on leaf width of 'Kitchener' mango cultivar

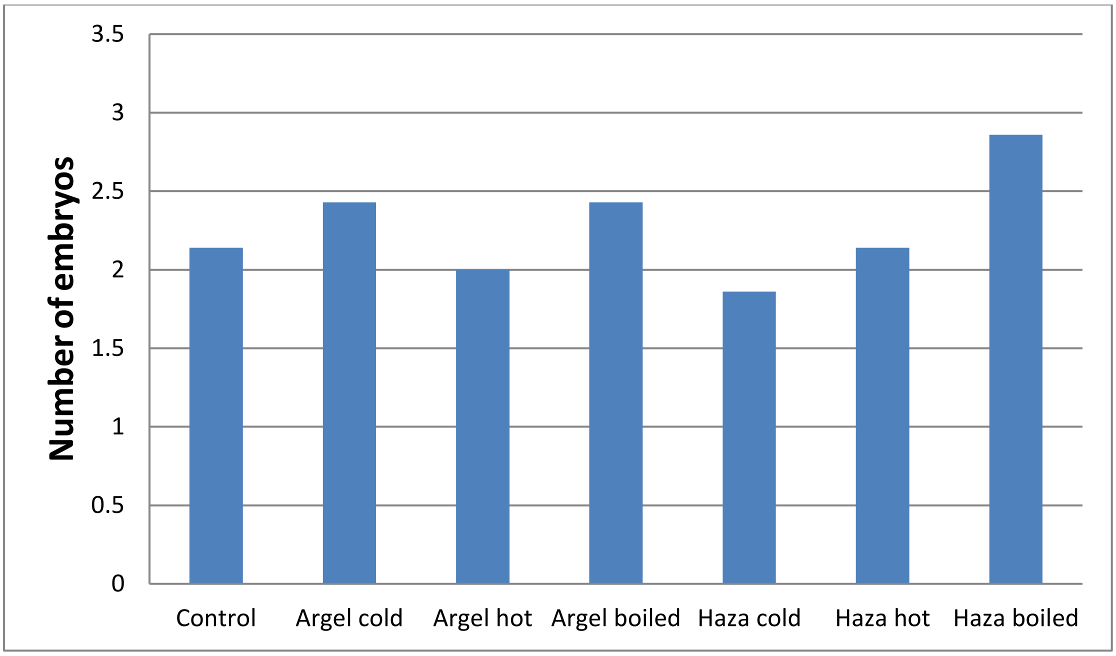


Fig.6. Effect of Argel and Haza plant shoots water extracts treatments on number of embryos of 'Kitchener' mango cultivar

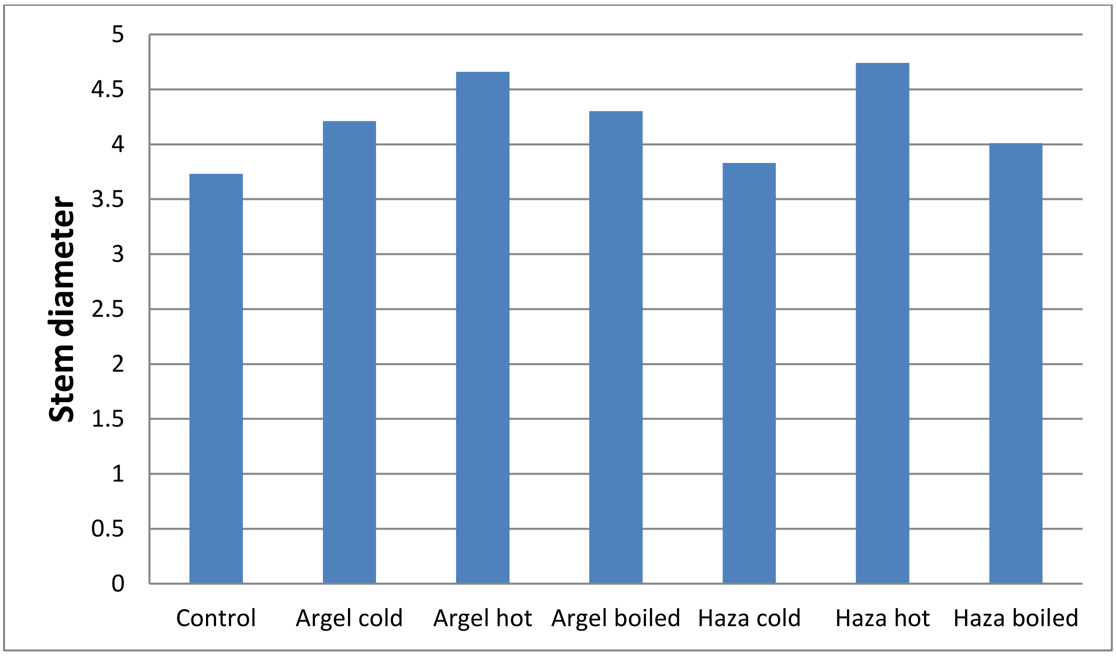


Fig.7. Effect of Argel and Haza plant shoots water extracts treatments on stem diameter of 'Kitchener' mango cultivar

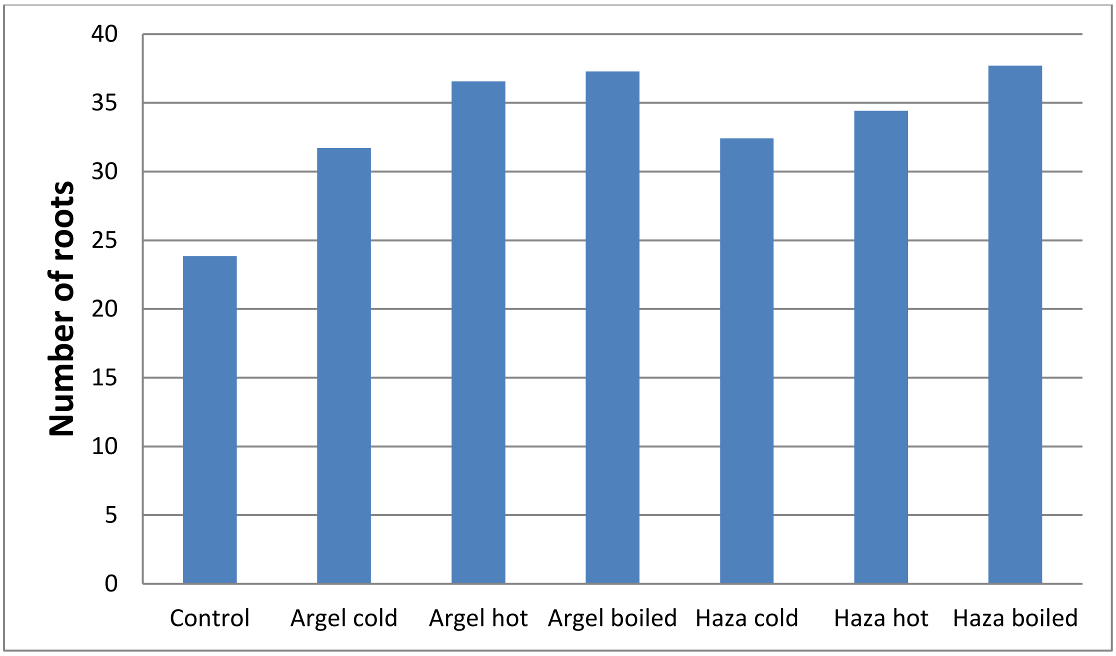


Fig.8.The effect of Argel and Haza water extracts treatments on number of roots of 'Kitchener' mango cultivar.

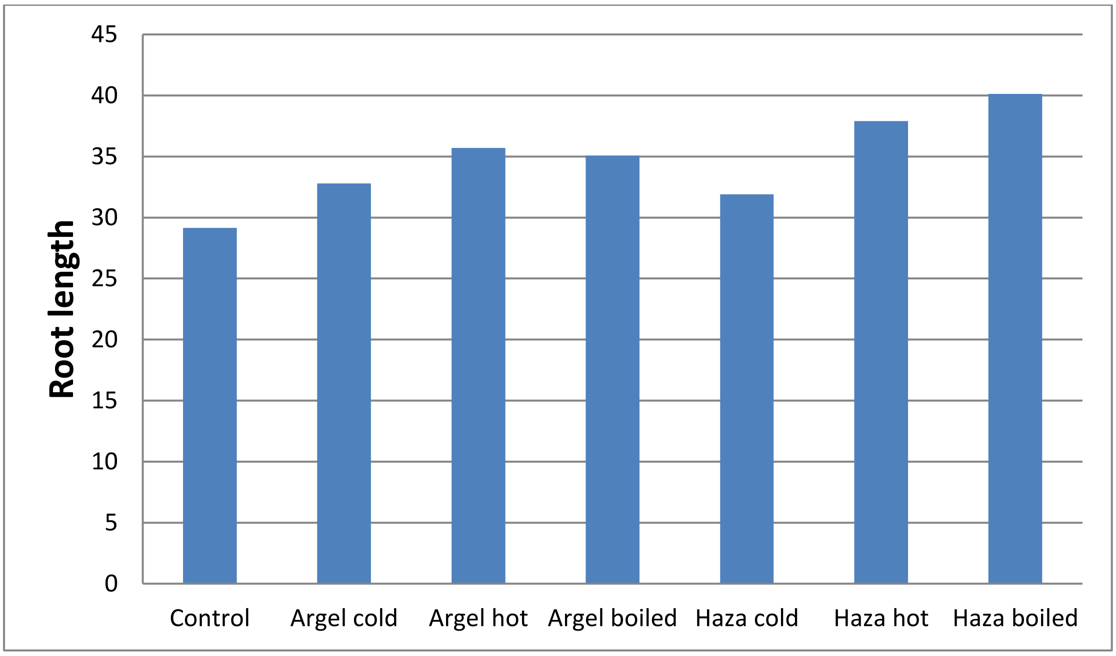


Fig.9. Effect of Argel and Haza plant shoots water extracts treatments on root length of 'Kitchener' mango cultivar**.**

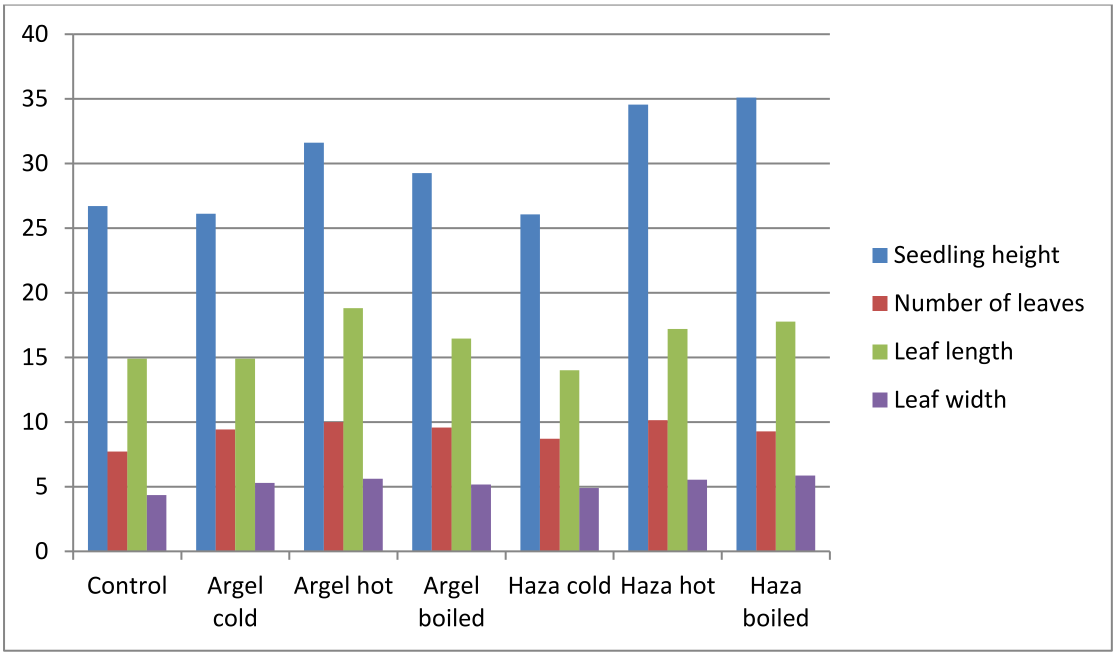


Fig.10. Effect of Argel and Haza plant shoots water extracts treatments on seedling height, number of leaves, leaf length and width.

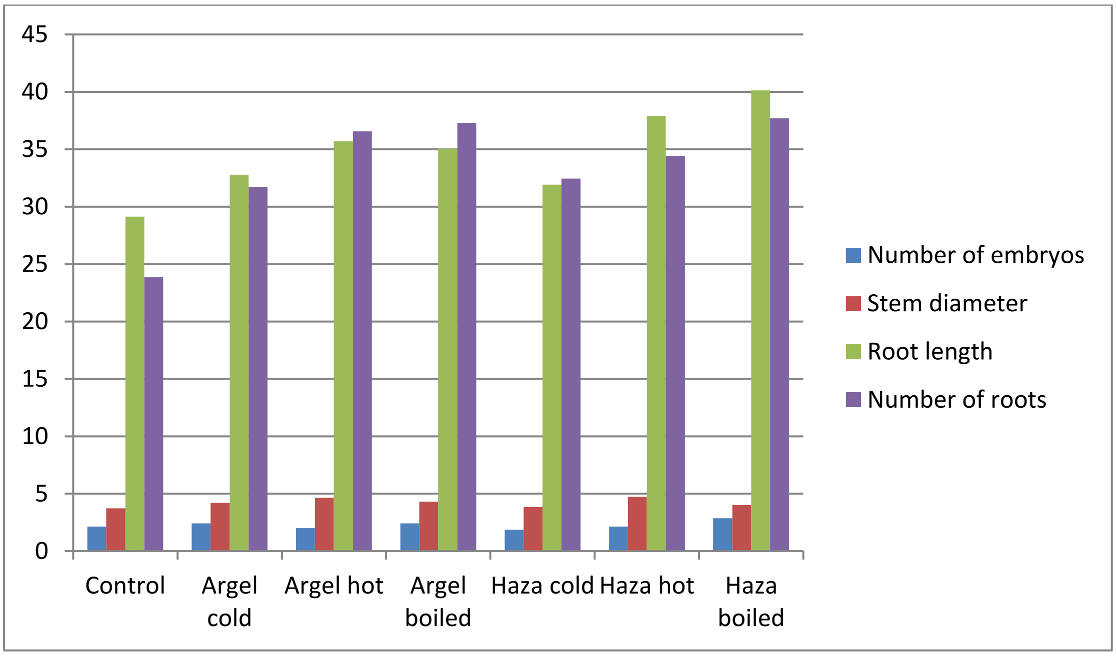


Fig.11. Effect of Argel and Haza plant shoots water extracts treatments on number of embryos, stem diameter, root length and number of roots.

CHAPTER FIVE

DISCUSSION

The results of this study revealed the benefits of submersing the decorticated mango seeds in Haza and Argel plant shoots extracts on both speed and percentage of seed germination, beside enhanced growth attributes of the resulting seedlings. The overall comparison between Haza and Argel plant shoots was in favor of Haza plant shoots for enhanced germination attributes. This finding is a basic primary report on the growth bio-stimulating potential of this plant as no such potential had been reported in literature according to our knowledge. However, the hot water extract of Haza plant shoots shortened the time to full germination and this may be owed to auxin-like effect. Endogenous auxins are normally activated at commencement of seed germination stage to promote water absorption and enlarge cell walls of the germinating embryos. Auxins also participate with cytokinins in cell division which is an active process during germination. As the graft-ability of mango rootstock is mainly influenced by seedling height and stem diameter, the hot water extract of Haza plant shoots proved to be most enhancive for these parameters without significant difference from the hot water extract of Argel plant shoots. Therefore, both are assumed to have growth bio-stimulating properties. The growth promoting property of Argel plant shoots had been recognized by Idris *et al*., (2011) in date palms as growth and yield attributes of Argel treated palms were promoted significantly. Likewise, Idris *et al*., (2014) reported significant enhancements in number of flowering branches, fruit set and fruit retention per panicle upon treatment with different forms of argel as part of integral management of malformation in 'Tommy Atkins' mango cultivar. They owed the effect to both pesticide and growth regulator-like effects of argel. Haza is a native of Northern Sudan where it grows wild along the banks of the Nile after the recession of river flood during autumn. No preceding results on its impact on plant growth or hygiene are available according to the reported literature. However, several alkaloids of pharmaceutical value had been isolated from the plant (Ulubelen and M. Öztürk, 2008, Al-Rehaily *et al*, 2001, Khalid and Waterman, 1981, Sheriha *et al* 1985.). It is noteworthy to recognize its use in Sudan ethno-medicine for treatment of troubled digestive and urino-genital systems. Due to the significant growth enhancements obtained from its use in this study, these findings may provoke further research interest to explore its potency in other agricultural uses.

In conclusion, growth stimulation had been achieved by the use of extracts of shoots both plants. Yet, although no definite interpretation of the benefits obtained in this study other than the probability of growth regulator-like effects of the constituents, the solid scientific interpretation requires thorough phyto-chemical analysis to define the active ingredients in both plants that caused the enhancements.

CHAPTER SIX

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CHAPTER SIX

APPENDICES

Appendix1.

Table of estimations of the cultivated area and production of mango in Sudan

Year	Area (Thousand hectares)	Production (Thousand tons)
2010	69.4	624.6
2011	70.0	630.0
2012	70.6	635.4
2013	71.2	640.8
2014	72.5	641.6
2015	73.2	941.7

Source: Horticulture Sector Administration, Sudan, 2009

Appendix2.

Plate1. Seeds planted in plastic bags

Appendix3.

Plate2. Emergence of seedlings

Appendix4.

Plate3. Development of seedlings

Appendix5.

Plate4. Variation in emergence of seedlings

Appendix6.

Plate5. Emergence of multiple shoots from a single seedling (poly embryony)

Appendix7.

Plate6. Development of multiple shoots from a single seedling (poly embryony)