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Effect of *Moringa oleifera* Leaf Extract (MLE) on Pepper Seed Germination, Seedlings Improvement, Growth, Fruit Yield and its Quality

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ABSTRACT

This study was carried out during the two summer seasons of 2014 and 2015 on pepper (*Capsicum annuum* L.) cv. California Wonder. The goals of this investigation were enhancing either the speed of pepper seeds germination or its percentage, produce healthy seedlings, vigour growth and improve fruit yield and its quality by using moringa leaf extract (MLE). The concentrations used of MLE extract were 2% - 4% - 6% in addition to 0% (tap water) as control. The moringa extract was added through two methods i.e., seed soaking treatment for 3 and 6 hours before planting the nursery and as plant foliar spray either on the seedlings during nursery stage or after transplanting in the open field . The obtained results indicated that moringa leaf extract at 4% concentration as seed soaking for 6 hours stimulated germination percentage, rate, index as well as coefficient of germination velocity. Moreover, the same concentration (4%) of MLE as a foliar spray on pepper seedlings in the nursery was sufficient to support all seedlings parameters expressed as height, fresh and dray weight, number of leaves and leaf area. Moreover, the maximum plant growth parameters as well as superior early and total fruit yield were obtained from the same treatment. Furthermore, MLE at concentration of 4% increased average fruit weight, length and diameter as well as fruit chemical contents such as carbohydrate, ascorbic acid and both of K and Ca elements. For that it can recommend that soaking pepper seeds in moringa leaf extract solution at concentrate of 4% for 6h for enhancing the germination percentage and seedling characteristics as well as spraying the seedling and pepper plants with 4% MLE solution to obtain superior fruit yield with best quality.

Key words: Pepper, moringa leaf extract, seed germination, seedlings vigor, plant growth, fruit yield and its quality.

Introduction

Pepper (*Capsicum annuum* L.) is considering an important fruit vegetable crop belong to family Solanaceae which remembered since more than 6000 years ago (Perry *et al.,* 2007). It is the second most important vegetable in the world after tomato for internal consumption and for export. Pepper fruit is rich in vitamins A and C and contain appreciable quantities of proteins and minerals Temu and Temu (2005) and Olaniyi and Ojetayo (2010). Pepper seed germination is considered a critical step in the development cycle of the plant, germination rate and seedling growth in pepper plants are very low comparing with the other vegetable seedlings. (Korkmaz and Korkmaz, 2009). Different pre-treatments have been investigated to improving rate of pepper seeds germination and seedling growth, some of these treatments are chemical and others are natural product such as moringa leaf extracts (Wien, 1997). *Moringa oleifera* are belonges to family Moringaceae which it is consider the most widly tropical trees. (Foidl *et al.,* 2001 and Shahzad *et al.,* 2013). The moringa leaf extract (MLE) is consider as a natural plant growth regulator where, it is a source of zeatin which it is natural derivative of cytokinin, proteins, vitamins E, phenolics, ascorbates, essential amino acid and several mineral elements, making to putting it as a potential natural growth stimulant, as mentiond by Emongor (2012), Rady *et al.* (2013), Howladar (2014) and Rady *et al.* (2015). Other reports have been showed that moringa extract play as a plant hormone which enhances seed germination, growth and yield of crops. MLE foliar spray improved crop performance, resulting from its role on vigorous plant growth, maintained optimum tissue water status, improved membranes stability, enhanced antioxidant content, as mentioned by Anwar and Bhanger (2003), Nagar *et al.* (2006) Yasmeen *et al.* (2012), Yasmeen *et*

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al. (2013) and Rehman *et al.* (2014). Many investigators reported that the effective concentrations of MLE were differing according to plants type. However, Phiri and Mbewe (2010) revealed that moringa leaf extract at concentration of (1:10) was forced beans to germinate early and increased duration to first germination by100%, also increased germination percentage of cowpea while the same concentration lead to reduction in groundnut germination seed. They added also that, this reduction may be attributed to that MLE contain an inhibitory substance for groundnut seed germination. Moreover, Basra (2011) illustrated that MLE at concentration of (1:30) was the most effective concentration for causing higher emergence rate and better early seedling growth of spring maize. Furthermore, the rate of cowpea seed germination was decreased with the increase concentration of MLE as reported by Moktar *et al.* (2012). Also, Muhammad (2015) reported that moringa leaf extract at 5% was encouraged cowpea rate germination and final germination percentage followed by concentration of 2%. Culver *et al.* (2012) found that moringa extract significantly increased tomato average fruit weight and plant height as well as yield and its components. Muhammad *et al.* (2013) found that tomato plant height, plant dry weight and fruit yield were significantly affected with aqueous moringa extract. Also, Bashir *et al.* (2014) revealed that moringa leaf extract significantly increased the average plant height, leaves number, number of branches and yield of tomato plant. Oluwagbenga and Odeghe (2015) mentioned that sweet bell pepper plant height; number of leaves, fruit weight and yield were significantly influenced by the application of moringa leaf extract. Aluko (2016) reported that the highest values of pepper plant growth and yield parameters were obtained with MLE foliar application at concentration of (1:20).

The aim of this investigation was to enhancing germination percentage of pepper seeds and reducing the period of seed germination, as well as obtaining vigour seedlings, improving fruit yield characterized with the best quality by using natural extract of *Moringa oleifera* leaves as seed soaking or foliar spray.

Materials and Methods

Preparation of Moringa Leaf Extract (MLE):

Moringa oleifera leaves were brought from Desert Research Institute of Ismailia branch, Egypt. 1 kg of moringa leaves were air-dried under shade for two weeks and subsequently grounded to reach powder case then mixed with 1 liter ethyl alcohol (80% aq.) using a blender. The extract was purified by filtering twice through (Whatman No. 1) filter paper. After purification the extract was subjected to a rotary evaporator to fully evaporate the alcohol and get the crude extract. The concentrations were prepared from the crude extract. 20, 40 and 60 ml from the crude extract were taken and diluted with 980 ml, 960 ml and 940 ml distilled water for reaching the concentration to 2%, 4% and 6% respectively according to (Bashir *et al.,* 2014), in addition the control treatment, i.e., tap water as seed soaking or foliar spray. The mineral content and chemical composition in moringa leaf extract were summarized in Table (1) and Table (2)

Table 1: The mineral contents of Moringa Leaf Extract (MLE).

Mineral contents (mg/100g.d.wt)							
Essential macro-elements					Essential micro-elements		
N (g/100g)	P	K	Mg	Ca	Fe	Cu	Zn
1.78	9.7	2.8	3.5	1.28	1.18	0.87	2.46

Table 2: Chemical composition analysis of moringa leaf extract according to Abdalla (2014).

Chemical composition	(mg/100g. d.wt)
Water	5.90
Protein	27.20
Fiber	19.20
Total sugar	38.60
Lipids	17.10
Ascorbic acid	3.26
Total carotenoids	2.24
Soluble phenols	2.24
Gibberellins	0.802
Zeatin	0.936

The previous concentrations, i.e., 2%, 4% and 6% were used in three separate experiments of pepper seeds, seedlings and pepper plants as the following.

First experiment:

Effect of seed soaking in MLE solution on germination tests:

The present experiment was conducted in the Laboratory of Vegetable Research Departments, Horticultural Research Institute, Giza Governorate. Seeds of sweet pepper (*Capsicum annum* L.) cv. California Wonder were soaked in cups filled with 200 ml of MLE solution at concentration of 0% (tap water) as control, 2%, 4%, and 6% under two soaking duration, i.e., 3 hours (H_1) and 6 hours (H_2). Seeds were sowing in Petri dishes above filtered paper Whatman No. 1, 100 seed /concentrate putted in 4 dishes. Every concentrate or soaking duration were distributed in separate dishes. After that, every dish moistened with 1 ml of distilled water for two days interval and left under room temperature with average of 24-26C^o till period of 14 days to complete germination processes. After 2 days from sowing the germination processes was check, whereas, the seeds were considered germinated when the emerging root had elongated to 2 mm. Then, germinated seeds were account every 2 day until day-14 to recording the germination measurements. The experiment was laid out in a split plot design with three replicates. Where, the concentrations were arranged in the main plot while the soaking duration was arranged in the sub plot.

Data recorded:

1- Germination percentage (GP %) = (Number of germinated seeds / Total number of seeds) × 100, according to (Scott *et al.,* 1984).
2- Germination rate (GR) = N_1 x D_1 + N_2 x D_2 + N_3 x D_3 + -------- / Total germinated seeds
Where: N = Number of germinated seeds per day, D = Number of days from the start of the count, according to (Scott *et al.,* 1984).
3- Co-efficient of Germination Velocity (CGV %) = $100 \times \sum N_i / \sum N_i T_i$
Where: Ni = Number of germinated seeds per day, Ti = Number of days from the start of the count, according to (Peyman and Yousef, 2014)

Second experiment:

Effect of spraying the seedlings with MLE in nursery:

This experiment was conducted in the green house of Vegetables Research Departments, Horticultural Research Institute, Giza Governorate. This investigation was carried out through two phases as follow:

First phase: *Seed soaking:*

Seeds of peeper plants were soaked in MLE solution at levels of 2%, 4% and 6% beside the control (soaking in tap water) for 6 hours according to the first experiment. The previous treated seeds were sowing in seedlings trays filled with peat moss: vermiculite 1:1 (v/v) in 10, 16 February 2014 and 2015 respectively. After 5 days from sowing seeds, the germination was check for recording the germination parameters and continues every day until day-15. The criterion used for germination was taken as emergence of 3 mm radical at the time of observation according to (Odoemena, 1988).

Data recorded:

1- Germination percentage (GP %) = (Number of emerged seedlings / Total number of seeds) × 100, according to (Adetimirin, 2008).
2- Germination rate (GR) = N_1 x D_1 + N_2 x D_2 + N_3 x D_3 + ------- / Total emerged seedlings

Where: N = Number of emerged seedlings per day, D = Number of days from the start of the count, according to (Adetimirin, 2008).

3- Germination index (GI) = $N_1/D_1 + N_2/D_2 + N_3/D_3$+----------
Where, N = Number of emerged seedlings per day, D= Number of days from the start of the count, according to Association of Official Seed Analysis (A.O.S.A, 1983)

Second phase: *Seedlings foliar spray:*

After appearance of the first true leaf the trays divided into two groups:

First group:
The developmental seedlings were left to continuous growing without foliar spray.

Second group:
The seedlings were sprayed with the previous solutions of MLE at the levels of 2%, 4%, 6% once every week till day-45.
The experiment was arranged in a randomized complete block design with three replicates.

Data recorded:
Ten seedlings per each concentrate were sampled at 45 days from sowing to measure the following data:

1- Seedlings height (cm), the vertical distance above the soil that the shoot reached were measured with a scale expressed in centimeters.
2- Seedlings fresh weight (g).
3- Seedlings dry weight (g). ten seedlings from each concentrate was taken and dried at 70 Cº till constant weight and the average dry weight of whole seedlings was determined using the standard methods as illustrated by (A.O.A.C, 1990).
4- Seedlings leaf area (cm^2) measured by Li-300 leaf area meter produced by Li-Cor, Pinclivania.
5- Number of leaves/seedling.

Third experiment:

Effect of foliar spraying with MLE on plants at development stage in the open field:
The present investigation was conducted at the experimental Farm of Qaha, Qalubia Governorate, Horticulture Research Institute, Agriculture Research Center during the summer seasons of 2014 and 2015. Pepper seeds without any treatment either soaking duration or MLE concentrations were sowing in foam trays filled with peat moss: vermiculite 1:1 (v/v) in 2, 10 February 2014 and 2015 respectively. Seedlings were transplanted in 20 and 25 Mars in two seasons respectively in the open field at 30 cm apart in one side of the ridge. The plot area was (11.76 m²) includes 4 ridges (4.2m length and 0.7m width). After 30 days from transplanting the plants were sprayed every 15 days interval (5 times spraying) by different treatments, i.e., 2%, 4% and 6% in addition to tap water as control. The fertilizers and other agricultural practices were done according to the recommendation of the Ministry of Agriculture for pepper plants in open field. The experiment was laid out in a randomized complete block design with three replicates.

A random soil samples were taken before planting for chemical and mechanical analysis as described by Chapman and Pratt (1961) and Jackson (1965). The farm had a clay loam soil texture; physical and chemical analyses are shown in Table (3).

Table 3: Soil physical and chemical analyses.

pH	E.C. (dsm^{-1})	$CaCo_3$ %	Soluble cations (M/L)				Soluble anions (M/L)				Macro elements (ppm)			Micro elements (ppm)			
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO^{-3}	Cl^{-2}	SO_4^{-2}	N	P	K	Fe	Cu	Zn	Mn
8.1	2.1	3.3	3.4	7.9	7.2	0.28	3.2	1.9	1.0	2.5	38	30	55.8	4.1	2.8	1.75	2.7

Data recorded:

1-Vegetative growth parameters:

A sample of five plants were chosen and taken randomly from each plot at the flowering stage (after 65 days from transplanting) in order to determine vegetative growth parameters i.e. plant height (cm), number of leaves and branches per plant as well as leaf area (cm^2) which measured by Li-300 leaf area meter produced by Li-Cor, Pinclivania. Total leaf chlorophyll content was measured using Minolta chlorophyll meter SPAD-501.

2-Fruit yield and its quality:

A sample of five sweet pepper fruits at edible stage were randomly taken from each plot at the second picking to determine the following data: fruit length (cm), fruit diameter (cm), average fruit weight (g). No. of fruits/plant (the all fruits picked from plot were account then divided on plant number in the same plot). Early fruit yield (ton/fed) was calculated as the total of the first, second and third pickings, while the total fruit yield (ton/fed) was estimated (the weight of the all pickings). A random sample of other three fruits from each plot was taken and dried at 70 C^o till constant weight and the dry weight of fruit was determined using the standard methods as illustrated by (A.O.A.C, 1990).

3- Chemical properties of pepper fruits:

Total calcium and potassium were determined in the green fruits on the basis of dry weight according to the methods described by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Chapman and Pratt (1961) respectively. Total ascorbic acid (Vitamin C, mg/100g fresh weight) content was determined using 2, 6 dichlorophenol indophenols, method as described by Ranganna (1979). Total Carbohydrates were determined colorimetrically using the method described in (A.O.A.C, 1990).

4-Statistical Analysis:

All data were subjected to statistical analysis according to the procedures reported by Snedecor and Cochran (1982) using M-stat program and means were compared by L.S.D multiple range tests at the 5% level of probability in the two seasons of experimentation.

Results and Discussion

First experiment: Effect of seed soaking in MLE solution on germination tests:

Data in Table (4) cleared that, soaking pepper seedlings in moringa leaf extract at concentrations of 2% and 4% have positive effect on seed germination tests expressed as germination percentage, germination rate and co-efficient of germination velocity. Concerning to the comparison between different concentrations, it noticed that the increment in germination parameters were in parallel with the increasing of concentrations from 2% till 4%. Hence, the level of 4% recorded the superiority percentage of germination and both of seed germination rate and coefficient germination velocity. On the other side, the control treatment (tap water) showed the lowest results of the previous parameters. These results may be attributed to moringa leaf extract which contain plant hormones, causing enhancing in seed germination (Yasmeen *et al.,* 2013 and Rehman *et al.*, 2014). Furthermore, the moringa leaf extract (MLE) is a source of essential amino acid and several mineral elements such as K and Ca, which consider a potential natural growth stimulants (Howladar, 2014 and Rady *et al.,* 2015). These results are agreement with those results obtained by (Iftikhar, 2009), who reported that maize seed treated with MLE solution recorded the high germination percentage, Also, Phiri and Mbewe (2010) revealed that moringa leaf extract forced beans to germinate early and increased duration to first germination by 100%, beside encouraging germination percentage of cowpea. Bashir *et al.*

(2014) reported that *M. oleifera* leaf extracts enhanced the germination of tomato seeds by 20-80%. Muhammad (2015) reported that moringa leaf extract at 5% encouraged cowpea rate germination and final germination percentage followed by MLE at concentration of 2%. On the contrary, the high level of MLE (6%) has inhibitor effect on previous parameters as compared to 2% and 4% levels as shown in Table (4). Same result was found by Moktar *et al.* (2012) on cowpea.

Table 4: Response of pepper seed germination to different concentrations of MLE in the two seasons of 2014-2015.

MLE concentrations	1st season			2nd season		
	GP (%)	GR (day)	CGV %	GP (%)	GR (day)	CGV %
0%	80.50	8.11	12.35	80.16	8.08	12.35
2%	91.33	7.40	13.11	92.17	7.37	13.23
4%	93.66	7.10	13.71	93.83	7.19	14.01
6%	88.00	7.68	12.50	88.17	7.53	12.61
L.S.D at 5%	0.70	0.04	0.10	0.74	0.01	0.08

GP: Germination percentage GR: Germination rate CGV: Coefficient of germination velocity

Regarding to the duration of seed soaking, data presented in Table (5) revealed that progress results in germination percentage, rate and co-efficient of germination velocity were correlated with increasing the duration of soaking from 3 hour to 6 hour which showed the highest values of the previous results. The obtained results are compatible with those of Mozumder and Hossain (2013), they reported that the maximum germination percentage and germination rate were obtained in seeds of *Eryngium foetidum* L when soaked for long duration in MLE solution.

Table 5: Response of pepper seed germination to soaking duration in MLE during the two seasons of 2014-2015.

Soaking duration	1st season			2nd season		
	GP (%)	GR (day)	CGV %	GP (%)	GR (day)	CGV %
H_1	87.25	7.61	12.81	87.50	7.67	13.00
H_2	89.50	7.57	13.02	89.66	7.41	13.10
L.S.D at 5%	0.36	0.03	0.04	0.46	0.01	0.05

GP: Germination percentage GR: Germination rate CGV: Co-efficient of germination velocity
H_1: Soaking period for 3 hours H_2: Soaking period for 6 hours

The obtained results illustrated that increasing concentration of MLE solution from 2% to 4% with 3 or 6 hours were capable to obtain the superiority results of germination parameters as shown in Figures (1, 2 and 3).While, the seeds were soaked in the highest concentration of MLE (6%) with either 3 or 6 hours lead to a reduction in the previous parameters. These results agreed with those of Mabhaudhi and Modi (2011), which they found that soaking maize seeds in high level of MLE solution caused imbibitions injury which cause decline in germination parameters.

Least Significant Differences (L.S.D) of the interaction between MLE concentrations and soaking duration on germination parameters of pepper seeds are shown in Table (6).

Table 6: Least significant differences of the interaction between MLE concentrations and soaking duration on germination parameters of pepper seeds in the two seasons of 2014 – 2015.

Least significant differences	1st season			2nd season		
	GP (%)	GR (day)	CGV %	GP (%)	GR (day)	CGV (%)
L.S.D at 5%	0.73	0.06	0.09	0.93	0.02	0.10

GP: Germination percentage GR: Germination rate CGV: Coefficient of germination velocity

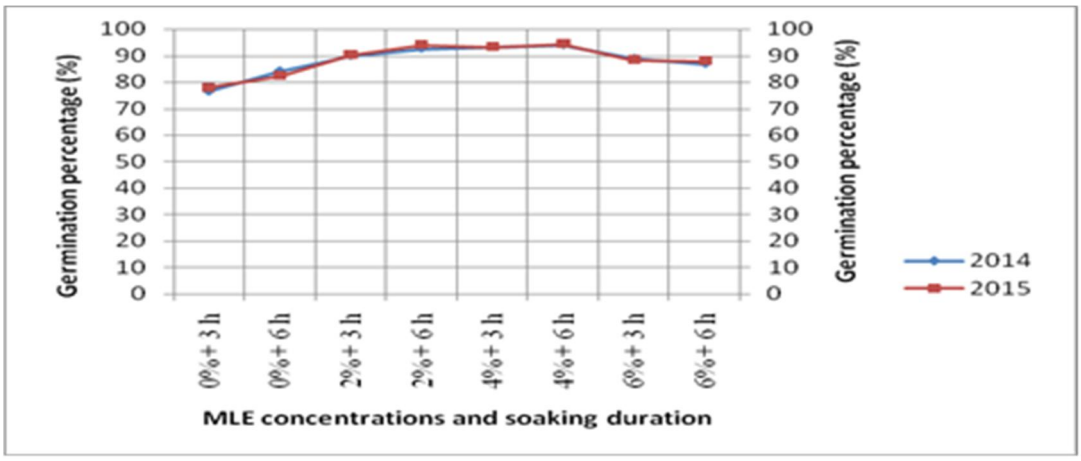

Fig. 1: Effect of the interaction between MLE concentrations and soaking duration on germination percentage of pepper seeds in the two seasons of 2014 – 2015.

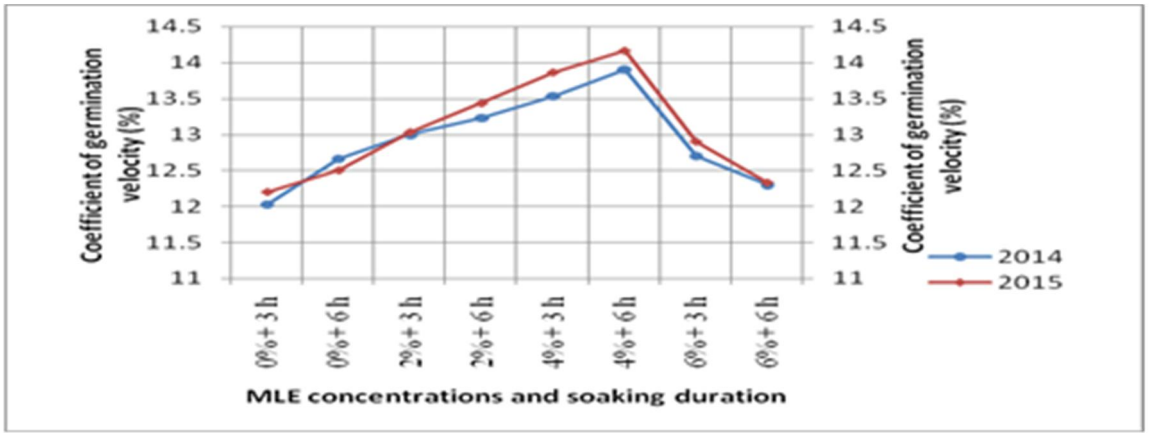

Fig. 2: Effect of the interaction between MLE concentrations and soaking duration on germination rate of pepper seeds in the two seasons of 2014 – 2015.

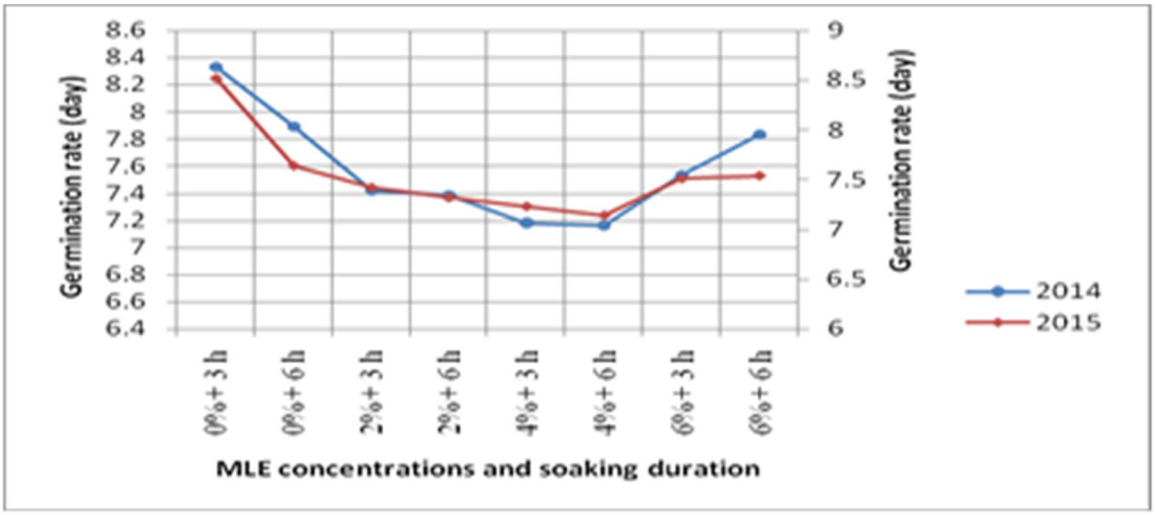

Fig. 3: Effect of the interaction between MLE concentrations and soaking duration on co-efficient of germination velocity of pepper seeds in the two seasons of 2014 – 2015.

Second experiment: Effect of spraying the seedlings with MLE:

First phase: Seed soaking:

Figures (4, 5 and 6) showed that all germination tests, i.e., germination percentage, rate and index were significantly affected by different MEL concentrations It is obvious that, the superior

results were achieved by soaking seeds in MLE solution at concentrate of 4% for 6 hours followed by both of 2% and 6% concentrates respectively with the same soaking period.

On the other hand, soaking seeds in tap water for the same period was insufficient to enhance the pervious measurements which registerated lowest values. These results were true in two growing seasons. The results of this study are similar with those found by Welbaum *et al.* (1998) on vegetables, Musa *et al.* (1999) on crop, Golezani *et al.* (2008) on lentil and Dennis *et al.* (2014) on falcata (*Paraserianthes falcataria*). These results may be attributed to that seed treated with MLE solution triggers a range of biochemical changes such as enzyme activation, starch hydrolysis and dormancy breaking as mentioned by (Aziza *et al.,* 2004). Also, MLE extract enhances mobilization of reserves from the storage of seed i.e., cotyledons or endosperms for partitioning to embryo or causes increase in amylase activity and reducing sugars, contributing to early vigor (Afzal *et al.,* 2012).So, the MLE extract can encourage seed germination percentage, rate and index as reported by (Wahid and Farooq, 2012 and Muhammad *et al.,* 2015). The Least Significant Differences (L.S.D) between the treatments are shown in Table (7).

Table 7: Least significant difference between the treatments for germination parameters of pepper seeds in the two seasons of 2014 – 2015.

Least significant differences	1st season			2nd season		
	GP (%)	GR (day)	GI	GP (%)	GR (day)	GI
L.S.D at 5%	2.34	0.02	0.02	1.61	0.09	0.69

GP: Germination percentage *GR: Germination rate* *GI: Germination index*

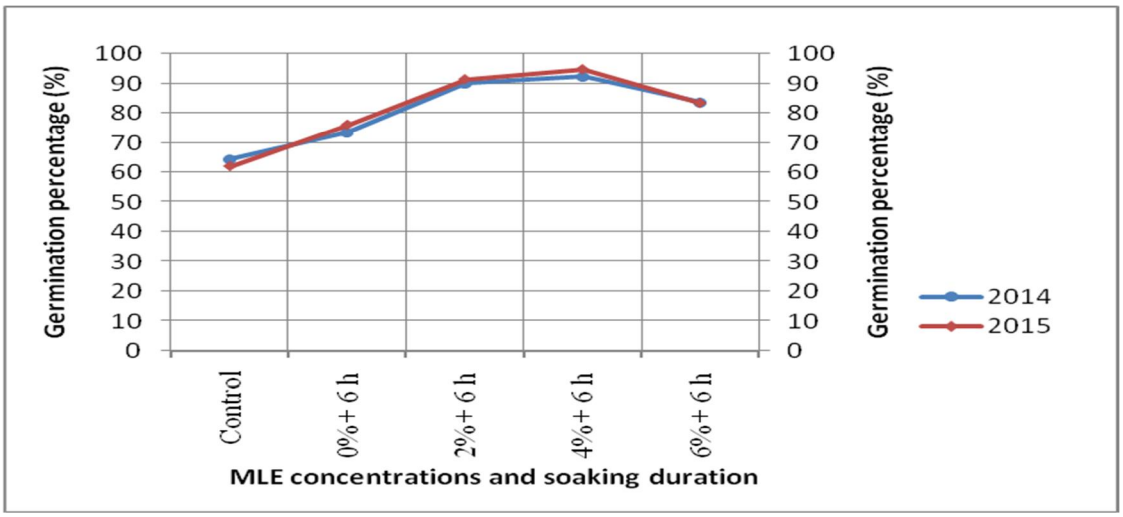

Fig. 4: Effect of MLE concentrations and soaking duration on germination percentage of pepper seeds in the two seasons of 2014 – 2015.

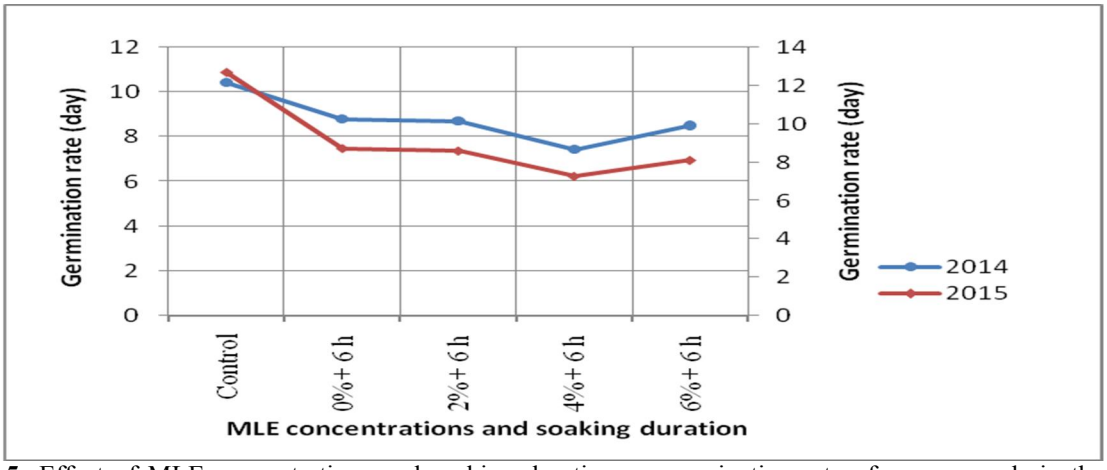

Fig. 5: Effect of MLE concentrations and soaking duration on germination rate of pepper seeds in the two seasons of 2014 – 2015.

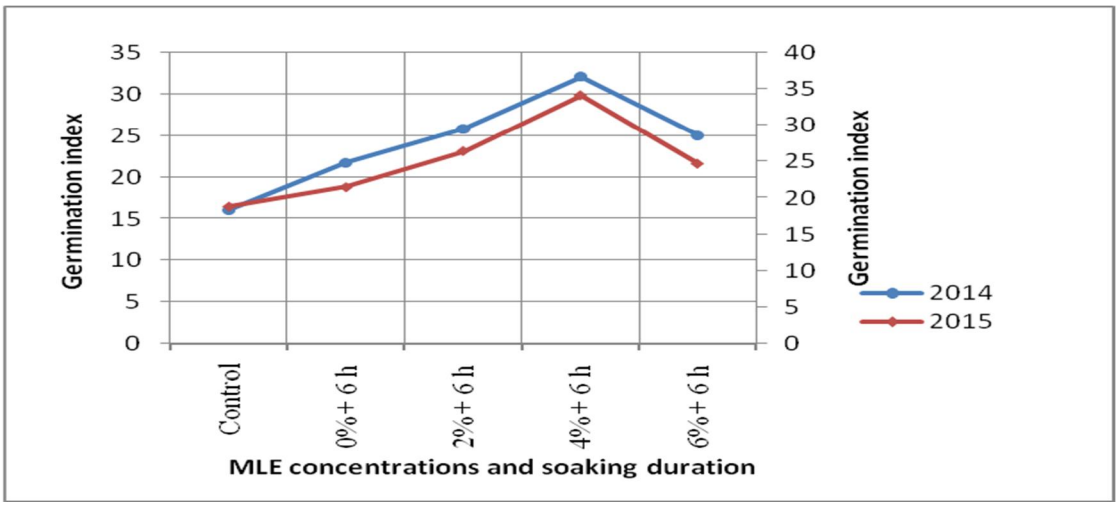

Fig. 6: Effect of MLE concentrations and soaking duration on germination index of pepper seeds in the two seasons of 2014 - 2015

Second phase: Seedlings foliar spray:

It can notice in Figures (7, 8, 9, 10 and 11) that, seedlings produced from seed soaking or continue treated with MLE solution by different concentrations as foliar spray in the nursery had significant positive effect in seedlings parameters i.e., seedling height, fresh weight, number of leaves/seedlings and leaf area. The favorable results were observed in the seedlings which sprayed by different MLE solution especially those were produced from soaked seed in MLE (4%) and sprayed with the same concentrate. Meanwhile, the lowest values were detected with those seedlings grown without soaking or spraying (control plant). Similar results were found by Basra (2011) who illustrated that MLE was the active inducer to obtain better seedling growth of spring maize compared to control treatment (tap water). The seedlings sprayed with MLE might provide strong and energetic start for earlier emergence and completed the growth improvement actively, whereas, this activeness due to strong seedlings growth (Rehman *et al.,* 2014). The activity effects of MLE solution may be attributed to the presence of growth-promoting substances in MLE extract that enhance seed germination parameters and improved seedling growth as reported by Muhammad *et al.* (2015).

The Least Significant Differences (L.S.D) between the treatments are shown in Table (8).

Table 8: Least significant differences between the treatments for pepper seedling stage in the two seasons of 2014 – 2015.

Least Significant differences	1st season					2nd season				
	Seedling height (cm)	Seedling fresh weight (g)	Seedling dry weight (g)	No. of leaves/ Seedling	Leaf area (cm^2)	Seedling height (cm)	Seedling fresh weight (g)	Seedling dry weight (g)	No. of leaves/ Seedling	Leaf area (cm^2)
L.S.D at 5%	0.08	0.04	NS	0.06	0.02	0.10	0.05	NS	0.01	0.45

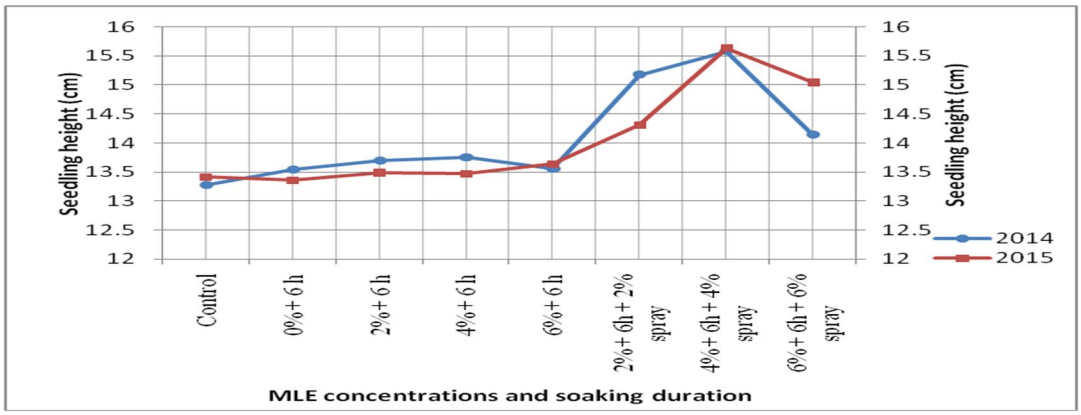

Fig. 7: Effect of MLE concentrations and soaking duration on pepper seedling height in the two seasons of 2014 – 2015.

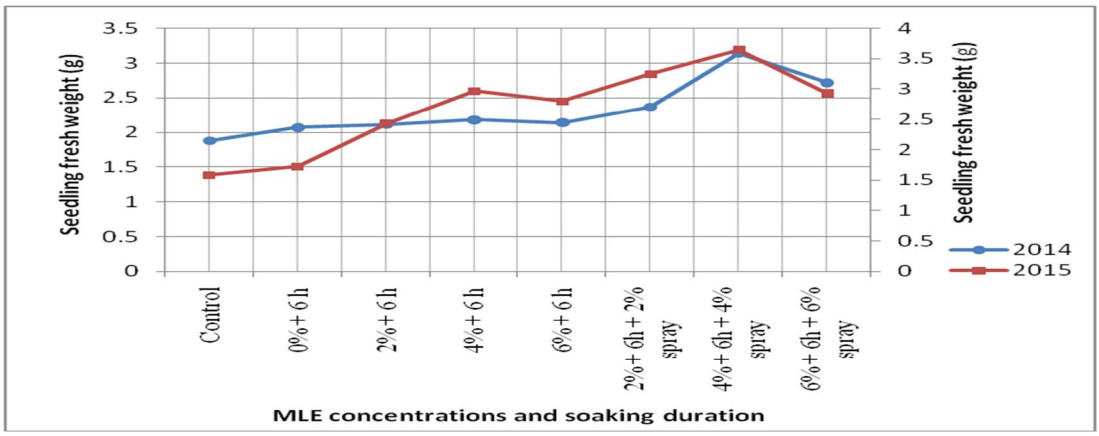

Fig. 8: Effect of MLE concentrations and soaking duration on pepper seedling fresh weight in the two seasons of 2014 – 2015.

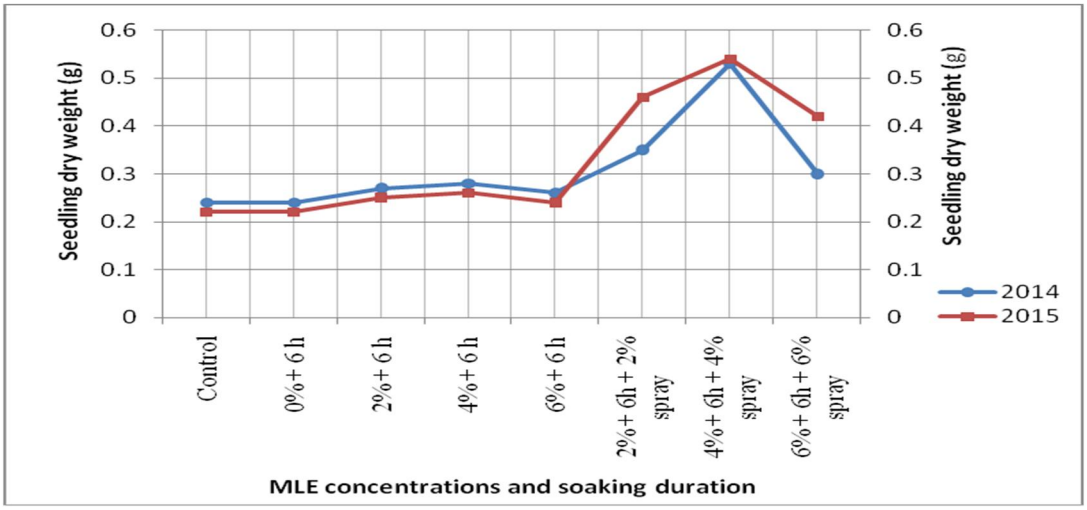

Fig. 9: Effect of MLE concentrations and soaking duration on pepper seedling dry weight in the two seasons of 2014 – 2015.

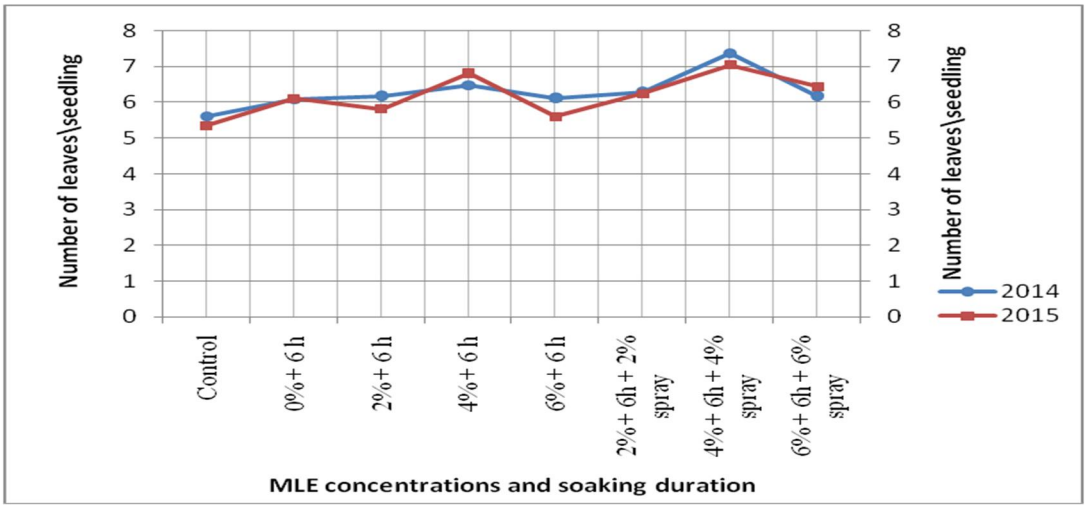

Fig. 10: Effect of MLE concentrations and soaking duration on number of leaves of pepper seedling in the two seasons of 2014 – 2015.

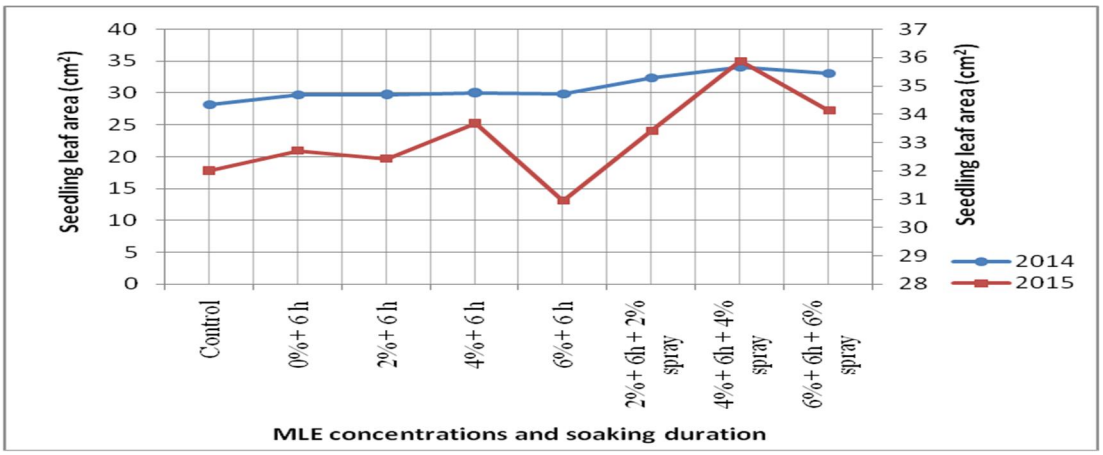

Fig. 11: Effect of MLE concentrations and soaking duration on leaf area of pepper seedling in the two seasons of 2014 – 2015.

Third experiment: Effect of foliar spray with MLE on pepper plants during vegetative growth stage:

1-Vegetative growth parameters:

Data in Table (9) showed the effect of spraying pepper plants with MLE extract at concentration of 2%, 4% and 6% on vegetative growth. It is obvious that all growth parameters were promoted with different MLE levels as compared to the control but the maximum vegetative growth expressed as plant height, more number of leaves, branches, larger leaf area and maximum leaf chlorophyll content were attributed to spraying the plants with the medium concentration (4%) of moringa leaf extract. This trend was clear in the both seasons. It may be due to fact of the medium concentration of moringa extract was enough to expand plant by substances which stimulate the growth. On the other hand, the chemical components incorporated in the moringa extract used as foliar spray in high concentration might be responsible to inhabit plant development as reported by (Pratley and Jellet 1997). Results of this study are confirm with those finding by Tetley and Thimann (1974), they reported that presence of zeatin like cytokinin in MLE extract maintains higher leaf area for photosynthetic activity and leaf chlorophyll content. Fuglie (2000) who deduce that leaf extracts of *M. oleifera* have been reported to accelerate growth of young plants, strengthen plants, and increase leaf area. MLE extract contains micro and macro essential elements and it is also rich and important in phyto-hormones such as indole-3-acetic acid (IAA), gibberellins (GAs) and zeatin as a cytokinin this diverse composition of MLE indicates that this extract can be used as a plant bio-stimulant (Yasmeen *et al.,* 2013 and Rehman *et al.*, 2014). Presence of cytokinin in MLE solution induces cytokinin biosynthesis which encourages the translocation of stem reserves to recent shoots due to healthy plant growth and prevents premature leaf senescence also maintains higher leaf area for photosynthetic activity which returned in high leaf chlorophyll content (Rady *et al.,* 2015). Bashir *et al.* (2014) found that tomato vegetative growth parameters were increased significantly with different concentrations of MLE extract. Also, Oluwagbenga and Odeghe (2015) on pepper and Zaki and Rady (2015) on *Phaseolus vulgaris* L.

Table 9: Pepper vegetative growth as affected by foliar spray with moringa leaf extract in the two growing seasons of 2014-2015

MLE concentrations	1st season					2nd season				
	Plant height (cm)	No. of leaves/ plant	No. of branches / plant	Leaf area (cm^2)	Chlorophyll (spad)	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	Leaf area (cm^2)	Chlorophyll (spad)
0%	44.63	163.36	5.20	209.66	46.32	41.84	156.00	4.80	188.10	47.10
2%	50.97	174.38	5.43	223.51	53.22	47.12	169.39	5.00	215.73	51.30
4%	55.70	190.03	5.60	257.17	57.16	50.14	181.03	5.80	246.23	55.40
6%	53.19	182.83	5.46	240.17	56.52	50.17	179.83	5.30	234.23	52.42
L.S.D at 5%	1.67	3.12	0.33	5.87	0.59	0.90	0.64	0.20	3.17	0.43

2-Fruit yield and its quality:

Concerning to the effect of different moringa extract concentrations on fruit yield and its quality, data in Table (10) showed that all levels of MLE lead to significant increases in fruit yield compared to the control treatment (Tap water) and at the same time enhanced its components, i.e., number of fruits/plant, fruit length, diameter, fresh and dry weight as well as early and total yield. Data also cleared that spraying pepper plant with moringa extract at concentration of 4% was sufficient to produce the superiority results of the previous parameters in the two growing seasons.
This significant results may be attributed to moringa extract concentration of 4% which caused increasing in pepper growth parameters, i.e., leaf area, chlorophyll content and number of leaves/plant as shown in (Table, 9) which maximized photosynthesis and increasing sink capacity through supply the photo-assimilates from leaves and translocation to build high quality fruit and yield as reported by Thomas and Howarth (2000), they illustrated also that application of MLE extract whereas it is rich with zeaten like cytokinin and this may be induced cytokinin bio-synthesis in turned maximum number of photosynthetic active leaves and that is obvious from number and area of leaves per plant maintaining the chlorophylls in higher concentrations which reflect on plant yield. Foliar application of moringa with low concentration contain sufficient amounts from stimulant substances encouraged increasing cell-division rate, cell-enlargement, strengthens plants, eventually produces more and higher yield (Fuglie, 2000). Also, Azooz *et al.* (2004) reported that the different concentrations of moringa extract was capable to enhance the photosynthetic apparatus in treated plant, which leads to increase in plant productivity and fruit dry matter. moringa leaf extract contains plant growth hormone, called zeatin which has been reported to increase yields by 25 to 30% for nearly any crop as mentioned by (Jason, 2013). These results are in agreement with those found by Palada (1996) who reported that yield of peanut, soya beans, sorghum and tomato was significant increasing when treated by foliar application with moringa leaf extract. Caceres (1999) deduced that *M. oleifera* extract contains high level of elements and hormone which make it act as growth and yield enhancer. Culver *et al.* (2012) revealed that moringa extract applied every two weeks up to harvest significant increases in tomato yield and its components as well as fruit dry matter. Ozobia (2014) reported that moringa extract as foliar application was improved eggplant yield and physical characters of fruit. The same results were reported by many researches Muhammad *et al.* (2013) and Bashir *et al.* (2014) on tomato Oluwagbenga and Odeghe (2015) and Aluko (2016) on pepper.

Table 10: Pepper fruit yield and its quality as affected by foliar spray with moringa leaf extract in the two growing seasons of 2014-2015

MLE concentrations	No. of fruits/ plant	Fruit length (cm)	Fruit diameter (cm)	Ave. fruit weight (g)	Fruit dry weight (g)	Early yield (ton/fed)	Total yield (ton/fed)
	1st season						
0%	8.25	5.27	5.42	56.73	9.24	1.11	4.72
2%	8.43	6.69	6.21	70.54	9.42	1.36	5.38
4%	8.83	7.11	6.74	78.39	10.35	1.73	5.94
6%	8.71	7.01	6.46	76.01	9.75	1.47	5.60
L.S.D at 5%	0.09	0.11	0.07	0.67	0.09	0.06	0.12
	2nd season						
0%	8.07	5.70	5.40	67.13	9.01	1.31	5.19
2%	8.38	7.03	6.34	75.42	9.81	1.43	5.57
4%	8.55	7.18	6.59	78.71	10.87	1.77	5.89
6%	8.46	7.10	6.45	75.73	10.15	1.56	5.71
L.S.D at 5%	0.11	0.11	0.07	2.07	0.11	0.03	0.09

3- Chemical properties of pepper fruits:

According to chemical properties of pepper fruits as affected by foliar spray with moringa extract, the results of foliar spray with moringa leaf extract compared with the control indicated an increase in chemical status of the pepper fruit due to application of moringa extract which improved

fruits chemical components i.e., K, Ca and carbohydrates as well as vitamin C content (%) as shown in Table (11). It is noticed that, the maximum values of chemical properties appearance in the fruits were harvested from plants sprayed with level (4%) of MLE. Meanwhile, the lowest results were observed with control treatment. This obtained result was true during the both seasons. These results may be attributed to moringa extract have high content of macro and micro elements (Table, 1) which enhanced the chemical components in fruits. This finding have also been supported by Yameogo *et al.* (2011) they found that *Moringa oleifera* extract have been reported to be a rich source of important minerals as Ca, Mg, K, Fe, Zn, P, S, Cu, Mn, Se and Na which boosted plants to accumulate progressively beneficial elements, which increase the plant nutrient status. Abdalla and El-Khoshiban (2012) said that accumulations of some nutritive elements as K and Ca in different parts of plants were increased as a consequence of treating by moringa leaf extract. These results are in agree with Mohammed *et al.* (2013), they reported that foliar spray with different concentrations of moringa extract increased minerals content and carbohydrate in onion bulb compared with untreated plants (control). Abdalla (2014) reported that rocket plants which sprayed with moringa leaf extract by either concentration of 2% or 3% recorded high chemical properties of K, Ca and ascorbic acid (vitamin C) in leaves. Zaki and Rady (2015) found that spraying *Phaseolus vulgaris* plants with MLE extract causes increasing in the concentrations of vitamin C content.

Table 11: Pepper fruit chemical contents as affected by foliar spray with moringa leaf extract in the two growing seasons of 2014-2015.

MLE concentrations	1st season				2nd season			
	Vitamin C mg/ (100g fresh wt.)	Carbohydrates (%)	K %	Ca %	Vitamin C mg/ (100g fresh wt.)	Carbohydrates (%)	K %	Ca %
0%	144.40	6.13	1.53	1.73	132.33	6.03	2.26	1.85
2%	151.75	6.65	3.41	1.87	140.84	6.41	2.55	2.07
4%	157.52	7.28	3.90	2.21	151.14	6.88	3.14	2.56
6%	156.10	6.93	3.36	2.07	146.54	6.90	2.94	2.24
L.S.D at 5%	2.35	0.10	0.05	0.06	1.12	0.06	0.11	0.04

Conclusion

As a general from this study, it can said that, spraying pepper plants with moringa leaf extract at concentration of 4% was the superior treatment to obtain the maximum values of vegetative growth, fresh fruit yield and its components as well as chemical constituents in the fresh fruits, i.e. K, Ca and carbohydrates as well as vitamin C content (%). Moreover it can by using moringa leaf extract at concentration of 4% for 6h duration as seed soaking treatment, it stimulate the rapid of germination furthermore enhances germination percentage and also as foliar application on seedlings stage where produce strong and healthy seedlings as well as in plant development phase.

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