Evaluation of Novel Nutrient Formulations for Use in Hydroponics.

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Abstract: An experiment was conducted with an aim of evaluating commercially available nutrient formulations for use in hydroponics. The locally nutrients formulations are modified crystallizer, modified polyfeed, and a standard (coffer formulation). These were tested in pails arranged in a completely randomized design. Electrical conductivity (E.C.) and pH measurements were maintained at 2.5-2.7mhos and 6.5 respectively. Aeration was provided using aquarium pumps to the lettuce and the cabbage roots to encourage root respiration. Final results of the experiment shows that a significant difference exist among the treatment means, there was a significant difference among the nutrient solution and the test crops for fresh weight, dry weight, leaf area, and crop growth rate (CGR). The difference among treatments was significant for, plant height, while coffer formulation and modified polyfeed produced the highest fresh weight mass of cabbage and lettuce vegetable crops. The choice for nutrient formulation to be used in hydroponics is no longer a problem as modified polyfeed has been proven in this work to be more promising, which is locally available in the market as Haifa polyfeed foliar fertilizer.
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1. Introduction

The term hydroponics refers to the science of growing plants in nutrients solution without the use of soil (Morard and Sylvester, 2004) In hydroponically grown plants the nutrient and the water are provided by nutrient solution alone and not by aggregates or other inert materials that support root growth, this method of producing plants have the same general requirement for good growth as soil grown plants such aeration, light, nutrient and water, the major difference is the method by which the plants are supported (Albright *et al,*. 1999). Hydroponic have a main objective of producing higher yield of quality vegetable crops as compared to the open field conventional type. Hydroponic systems are usually enclosed in greenhouse type structure such as shade net, plastic polythene, or glass house (Kassel *et al.,* 2005). Hydroponic culture is being used successfully to grow vegetables, flower, fruits, and herbs in a great variety of countries across the world such as United States, Britain, South Africa, and Asia where commercial practice of hydroponic is done since 1950s (Tachbana *et al.,* 1991; Veen, 1998). The leafy head of cabbage is eaten raw as food especially the spherical cluster of immature leaves excluding the partially unfolded outer leaves, cabbage is used in a variety of dishes because of its natural spicy flavor, the cabbage head is widely consume raw, cooked or preserved in a great variety of dishes, it's often added to stews and soup. Lettuce is best eaten raw; the mixture of the green can be tossed with a dressing for a simple salad. It can also be sliced with squash, and cooked. corn and potatoes which makes a healthier salad, adding beet, chicken, ham, cheese and egg to the green can serve as a delicacy. *Lactuca sativa* l is classified in section Lactuca subsection *lactuca l serriola* and other related species (Ferrentinos, K.P. 2002).

For instance lactuca *virosa, lactuca saligna and lactuca sativa* consisting of the cultivated material showing a large diversity. The edible genotypes have been arranged in six lettuce cultivation groups*: butter-head, cos, latin, crisphead*, cutting and stalked lettuce (Rodenburg, 1990) its still not exactly known which specie were evolved in the domestication of lettuce but its certain that *lactiva serriola* is one of the direct ancestor of the cultivated lettuce (Kesschi *et al.,* 2004) *Lactic sativa* L – is a leafy green vegetable branches of the first order extends laterally to a distance of six to eight inches (15 to 20cm) and then turn downwards, branches of the second order are numerous (Kassel *et al.,* 2001).

2 Materials and method.

Experimental design.

Factorial combination of two crops (lettuce, cabbage) and three nutrient formulations (coffer formulation as standard, polyfeed foliar fertilizer, and modified crystallizer) gave a treatment combination of six replicated three times arranged in a completely randomized design leading to eighteen treatment combinations.

Standardization of treatments

Table 1.1 shows the nutrient formulations to be evaluated with some modification. A standard concentration (coffer formulation) of nutrient compounds in parts per million (ppm) were used to standardized crystallizer and polyfeed so that all the treatment will have the same strength of stock solution, part per million requirement of nutrients in the standard were converted to gram equivalents. In polyfeed, percentages were converted to part per million and later to grams which were weighted and dissolved in 5Litre stock solution except for crystallizer which was calculated for 3.8L stock, nutrient lacking in polyfeed and crystallizer were supplemented which lead to their modification.

Table 1. three nutrient formulations evaluated for their effectiveness in hydroponics

Coffer formulation (standard)		Standard		Modified crystal		Poly feed
NUTRENT	PPM	g/5L	g/3.8L	g/3.8L	g/5L	g/5L
STOCK A						
Calcium Nitrate	N,200	1114.0	-	846.0	112.0	112.0
STOCK B						
Potasiumdihydrogenpho	P,60	292.0	115	115.0	191.0	191.0
Potasiumnitrate	K,300	647.0	304.0	304.0	205.0	205.0
Calcium Nitrate	Ca,170	188.0	157.0	157.0	156.0	156.0
Magnesiumsulphate	Mg,50	570.0	62.0	62.0	96.0	96.0
Boric acid	B,0.2	1.9	-	1.9	-	1.9
Coppersulphate	Cu,0.1	0.4	-	0.4	-	0.4
Ammoniummolybdate	Mo,0.2	0.5	-	0.5	-	0.5
Zincsulphate	Zn,0.1	0.5	-	0.5	-	0.5
STOCK C						
Ironsulphate	5560mg/L		11.0	11.0	1.7	1.7
SodiumEDTA	7460mg/L					

Nursery Management

Cabbage seeds, known as hybrid cabbage Victoria F1 treated with thiram with a germination percentage of 99%, packing date, August, 2010 and an expiry date of August 2012, registered as royal bluis® a product imported from Holland was purchased. Also with a lettuce seed known as lettuce great lakes 659 treated with thiram and malathion with an expiry date of December 13, 2014, which is resistant to heat and bolting and also tolerant to necrosis was purchased for the experiment, these seeds were sown on a sponge form with spacing of 4cm by 3cm for cabbage and 4cm by 2.5cm for lettuce as recommended and placed on a germination.

Electrical conductivity and pH.

The Electrical Conductivity Should be maintained between the range of 11 to 12 dsm^{-1} for optimum plant nutrient utilization in hydroponic solution (Goto *et al.*, 1991). Electric conductivity in hydroponics gives the ionic strength of nutrient solution for optimum plant utilization which ranges from 2.5-3.0 mhos this range was maintained using an electric conductivity meter. The optimum mineral composition of nutrient solutions was described by (Both *et al,.* 1999) which clearly resemble half strength Hoagland solution whose pH Should be maintained between 6.5 to 6.7 this range of hydrogen ion concentration was maintained by adding few drops of sodium hydroxide and hydrochloric acid depending on the ionic strength of the solution.

3 Result

Fresh weight (g) per plant of cabbage and lettuce as influence by different nutrient formulations.

Table 2. fresh weight(g) per plant of cabbage and lettuce a as influence by different nutrient formulation Week After Transplanting

NUTRIENT(N)	3	5	7	9
Coffer formulation	2.5^{a}	5.2^{a}	12.3^{a}	21.2^{a}
modified polyfeed	2.7^{a}	5.1^{a}	11.1^{a}	19.4^{a}
modified crystallizer	1.3^{b}	2.9^{b}	5.3^{b}	5.6^{b}
TEST CROPS (T)				
Cabbage	2.3^{a}	5.6^{a}	11.5^{a}	13.1^{b}
Lettuce	2.0^{a}	5.9^{a}	8.2^{b}	17.8^{a}
NT Interaction	*	*	*	*
CV%	19.33	17.8	14.2	17.9

Means with different letter(s) within a treatment group are significantly different using least significant difference(L.S.D) at 95% level of significance. ns =not significant, * = significant at 95% level of significance, ** = significant at 99% level of significance.

Significant differences was recorded at the third, fifth, seventh and ninth week after sowing for the three

nutrient formulation, (Table 1) coffer formulation and modified polyfeed produced the highest fresh weight while there was no different response between the two test crops at the third and the fifth week, while cabbage has a better performance than lettuce at the seventh week. Interaction between the test crop and nutrient formulations were all significant at all the weeks, coefficient of variation for the third week recorded the highest variability among the raw values obtained from the fresh weight.

Dry weight

The effect of nutrient formulation on the dry weight of cabbage and lettuce is shown in Table 5 Coffer formulation and modified polyfeed which are the same with each other were consistently superior to modified crystallizer throughout the sampling period. The trend is the same for the test crop as they have shown a consistent similar dry weight mass throughout the sampling period, which disagrees with (Albright *et al.,*1999) Root and shoot growth for lettuce plants grown in a floating hydroponic system gave a root dry mass of 0.8g after 45 days of seeding.

4 Discussion

Fresh weight and Leaf area

The effect of nutrient formulation on the fresh weight per plant of cabbage and lettuce is shown in Table 2, modified polyfeed and coffer formulation which are the same with each other throughout the sampling period are consistently superior to modified crystallizer, the trend is not the same with the responds of the test crops as cabbage and lettuce are the same at 5 and 6 weeks after transplanting (WAT), cabbage is superior to lettuce at 7WAT and lettuce is superior to cabbage at 9WAT in terms of fresh weight mass of averaged 25g after 60 days. Which disagrees with (Chiu *et al.,* 1995) who reported that an averaged fresh mass of 90g was obtained for lettuce hydroponic cultivation 45 days after seeding and a 110g fresh weight for cabbage plant. The effect of nutrient formulation on the leaf area per plant of cabbage and lettuce is shown in Table 3. Coffer formulation, modified polyfeed, and modified crystallizer are similar at 3WAP. At 7WAT the trend is not the same as modified polyfeed is superior to coffer formulation followed by modified crystallizer, at 9WAT coffer solution and modified polyfeed are superior to modified crystallizer. The trend is not the same with the responds of the test crops as cabbage shown a significantly higher leaf area than lettuce at 7WAP while for third, fifth, and the ninth WAT cabbage and lettuce have the same leaf area. shoot growth for lettuce plants grown in a floating hydroponic system gave a root dry mass of 0.8g after 45 days of seeding.

Conclusion.

Hydroponics is suitable for urban areas where they do not have much land for cultivation; this method of crop production can also be practice as a hobby for gardeners who wish to cultivate cabbage and lettuce close to their backyard. Evaluation of nutrient formulation for use in hydroponics was done with the aim of knowing the best locally available nutrient formulation for use in hydroponics using high value crops. At the end of twelve weeks of experiment the following findings were made. Modified polyfeed fertilizer and modified crystallizer can provide iron without the presence of iron EDTA which kept the nutrient in solution. Crystallizer does not have all the needed nutrients required for plant growth. The following element were supplemented to produce modified crystallizer which are calcium nitrate, boric acid, ammonium molybdate, copper and zinc sulphate. Nutrient compounds were also missing in polyfeed.

Provision of Aeration

Deficiency of oxygen reduces water and mineral uptake with the subsequent destruction of the aerial part of the plant (Molard and Silvestre, 1996). Aeration was also provided manually, by agitating the nutrient solution, In order to produce oxygen bubbles. Aeration pumps were also connected to electricity in the green house to oxygenate the plant roots in the nutrient solution so as to avoid anaerobic respiration, which will prevent the utilization of the nutrients. Deficiency of oxygen reduces water and mineral uptake with the subsequent destruction of the aerial part of the plant (Thompson,1999).

Electrical conductivity and pH.

The Electrical Conductivity Should be maintained between the range of 11 to 12 dsm^{-1} for optimum plant nutrient utilization in hydroponic solution (Goto *et al.*, 1991). Electric conductivity in hydroponics gives.

Data analysis.

The data collected from the two by three factorial design arranged in a completely randomized design was analyzed using SAS software version 9.1 by invoking the PROC GLM on the software. Mean separation was done using the least significant difference shows which of the main treatment effect is significant and their interactions.

Leaf area (g) per plant of cabbage and lettuce as influence by different nutrient formulation.

Nutrient formulations for the third week are the same, similar trend follows for the fifth week, at the seventh week; modified polyfeed produced the highest leaf area followed by coffer formulation very poor leaf area was obtained from modified cystallizer (Table 3). At the ninth week modified polyfeed still produced the highest leaf area followed by coffer formulation and a poor performance from modified crystallizer. The

highest variability among the nutrient formulations and the test crops was recorded at the fifth week after sowing and the lowest at the seventh week after sowing.

Table 3. leaf area (g) per plant of cabbage and lettuce as influence by different nutrient formulation

Week after transplanting				
NUTRIENT	3	5	7	9
Coffer formulation	10.3[b]	17.3[a]	63.9[b]	79.2[a]
modified polyfeed	7.2[b]	19.0[a]	80.2[a]	90.3[a]
modified crystallizer	3.7[b]	12.2[a]	14.7c	18.9[b]
TEST CROPS				
Cabbage	5.7[a]	30.7[a]	59.6[a]	63.1[a]
lettuce	8.4[a]	29.3[a]	46.2[b]	62.2[a]
NT Interaction	*	NS	*	*
CV%	49	30.5	17.6	23.1

Plant height of cabbage and lettuce as influence by different nutrient formulation

Table 4. plant height of cabbage and lettuce as influence by different nutrient formulation

Week after transplanting				
NUTRIENT	3	5	7	9
Coffer formulation	5.3[a]	6.5[b]	9.7[b]	15.7[a]
modified polyfeed	5.2[a]	5.2[a]	12.1[a]	16.0[a]
modified crystallizer	3.2[b]	3.9[c]	4.9[c]	7.3[b]
TEST CROPS				
Cabbage	5.0[a]	7.7[a]	8.0[b]	12.2[a]
Lettuce	4.0[b]	4.9[b]	9.8[a]	13.7[a]
NT Interaction	*	NS	*	*
CV%	12.3	5.1	9.7	12.6

At the third week of plant height, coffer formulation and modified polyfeed exceed the height obtained from modified crystallizer, at the fifth week, coffer formulation produced the longest height followed by modified polyfeed, and modified crystallizer, the same trend follows at the seventh week. Modified crystallizer had the poor plant height. Cabbage and lettuce had the same performance at the third week, cabbage out yielded lettuce at the third week, and the ninth week cabbage and lettuce produce the same result, all interactions were significant except for the fifth week which was not significant.

Plant height

The effect of nutrient formulation on the plant height of cabbage and lettuce is shown in Table 4 coffer formulation and modified polyfeed are significantly the same for the third and the ninth week, fourth, fifth and the ninth week but superior to modified crystallizer at 3WAT, however the trend is not the same at 5WAT as modified polyfeed is inferior to coffer solution followed by modified crystallizer, the trend followed the same pattern at 7WAT. Coffer solution and modified polyfeed are significantly different and superior to modified crystallizer at 9WAT. The response of cabbage and lettuce between 3 and 5WAT are similar with cabbage been consistently superior while at 7WAT lettuce is superior to cabbage, at 9WAT lettuce and cabbage respond significantly the same. Which agrees with (Kassel *et al.,*1987) who reported that *lactuca sativa* is a leafy green vegetable, branches of the first order extends laterally to a distance of six to eight inches (15 to 20cm) and then turn downwards, branches of the second order are numerous.

Dry weight

The effect of nutrient formulation on the dry weight of cabbage and lettuce is shown in Table 5 Coffer formulation and modified polyfeed which are the same with each other were consistently superior to modified crystallizer throughout the sampling period. The trend is the same for the test crop as they have shown a consistent similar dry weight mass throughout the sampling period, which disagrees with (Albright *et al.,*1999) Root.

Which were supplemented to produce modified polyfeed which are boric acid, ammonium molybdate, copper and zinc sulphate. The choice for nutrient formulation to be used in hydroponics is no longer a problem as modified polyfeed has been proven in this work to be more promising, which is locally available in the market as Haifa polyfeed foliar fertilizer.

Table 5. Dry weight g per plant of cabbage and lettuce as influence by different nutrient formulation.

Week after transplanting				
NUTRIENT	3	5	7	9
coffer formulation	0.08[a]	0.35[a]	0.70[a]	1.21[a]
modified polyfeed	0.08[a]	0.33[a]	0.6[a]	1.11[a]
modified crystallizer	0.04[b]	0.09[b]	0.4[b]	0.33[b]
TEST CROPS				
Cabbage	0.07[a]	0.35[a]	0.6[a]	0.78[a]
Lettuce	0.06[a]	0.41[a]	0.5[a]	0.94[a]
NT interaction	*	NS	*	*
CV%	30.4	24.5	17.2	15.3

Plate 1. lettuce grown on coffer formulation at 7 weeks after transplanting

Plate 2. lettuce grown on modified polyfeed at 7weeks after transplanting

Plate 3. lettuce grown on modified crystallizer at 7weeks after transplanting

Plate 4. lettuce grown on modified crystallizer at 7weeks after transplanting

Plate 5. Lettuce grown on coffer formulation.

Plate 6. Cabbage, grown on coffer formulation at 9 week after transplanting

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