INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

EVALUATION OF INTERACTION EFFECTS OF NITROGEN AND PHOSPHOROUS ON YIELD AND QUALITY OF WATERMELON {*Citrullus lanatus* (Thunb.) Matsumara & Nakai}

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ABSTRACT
Field experiment was conducted in KARI, Matuga, Kwale District in the coastal region of Kenya for two seasons to test the interactive effects of nitrogen and phosphorous on yield and quality of watermelon [*citrullus lanatus* [Thumb]. Mansf.]. The fertilizer treatments were three levels of phosphorous (0, 50 and100 Kg P_2O_5/ha) applied in the form of triple super phosphate (TSP 46% P_2O_5) and four levels of nitrogen (0, 40, 80 &120kgN/ha) applied in the form of CAN (26% N). The experimental design was a Split-plot embedded in a Randomized Complete Block Design (RCBD) with three replications. The interaction between nitrogen and phosphorous had a positive significant effect on number of days to flowering, number of fruits/plant, fruit weights, firmness, rind thickness, total soluble solids and no significant difference in sex expression ratio. For improved growth, yield and quality of water melons in the coastal region of Kenya 50 Kg P_2O_5/ha and120KgN/ha was recommended.

KEYWORDS: Water melon, 'Sugar baby', phosphorous, nitrogen, interaction, yield, quality.

INTRODUCTION
Watermelon (*Citrullus lanatus*) is one of the most widely cultivated crops in the world (Huh *et al*., 2008). Its global consumption is greater than that of any of the cucurbit family member. It accounts for 6.8% of the world area devoted to vegetable production (Goreta *et al*., 2005). China is reportedly the leading country in production (Huh *et al*., 2008) with the average world production of watermelon being 98,600,915 metric tons and 4,412,042 metric tons in Africa (FAO, 2007). Twelve thousand varieties of watermelon are grown worldwide (Zohary and Hopf, 2000) and several of these varieties have been recommended for different climatic ranges in Kenya. These include 'Sugarbaby', 'Crimson Sweet', 'Charleston Gray', 'Chilean Black', 'Congo', 'Fairfax' and 'Tom Watson' (Tindall, 1983). However, among these cultivars, only the first three are available in Kenyan markets with 'Sugarbaby' being the most popular because of its sugary taste, smaller size, earlier maturity and higher yields (HCDA, 2006). Watermelons are a good source of water in the diets of human beings, but can also be used for making jams and other preservatives including jell preparation as well as in flavoring drinks and smoothies. The demand for watermelon in Kenya is higher than production resulting in the fruit being very expensive. With local demand unsatisfied, its potential for export cannot be realized. To meet the local demand and may be create some surplus for export, production of watermelon in Kenya needs to be increased (HCDA, 2006). One of the major challenges currently facing watermelon farmers in Kenya is low yields and poor quality due to heavy or low fertilization especially of nitrogen (HCDA, 2006). The current recommended fertilizers are calcium ammonium nitrate (CAN) at the rate of 80 Kg N/ha and triple super phosphate (TSP) at the rate of 100 Kg P_2O_5/ha and 0 Kg/ha of K_2O (MOA, 2003). Many farmers have, however, complained of heavy vegetative growth, low fruit yield and poor quality upon use of fertilizer rates. On the other hand, Potassium, has been tested on most Kenyan soils especially in the coastal areas, and found to be sufficient, thus no need for additional K fertilization (Kanyanjua *et al*., 2006). This study was carried out with the main objective of improving water melon yields in the coastal regions of Kenya by determining variety 'sugar baby' response to N and P under fertilization.

MATERIALS & METHODS
Field experiments were conducted at KARI, Matuga, Kwale County in the coastal regions of Kenya, for two seasons (April to August 2012, February to June 2013). Experiment was designed as a split plot experiment embedded in a Randomized Complete Block Design (RCBD). The factors studied included; Calcium ammonium nitrate fertilizer (26% N) providing the Nitrogen nutrient which was the main plot factor, whereas Triple Super Phosphate fertilizer (TSP, 46% P_2O_5) provided the phosphorus nutrient (P_2O_5). The nitrogen levels were: 0, 40, 80 and 120 Kg N/ha, and Phosphorus, levels were 0, 50 and 100 Kg P_2O_5/ha (Table 1). TSP was applied at planting in the planting holes and thoroughly mixed with top soil. CAN was split applied as a top dress first four weeks after planting then three weeks later. The treatments were laid out in a randomized complete block design replicated three times. Before land preparation, pre-plant soil samples were obtained from the upper soil surface layer (0 - 20 cm), using the transverse method. Twenty days after planting soil samples were obtained randomly in each plot within the rows from four locations

bulked together to make a composite sample. The soil samples were air dried sieved through 2mm mesh screen and analyzed for pH (soil: H2O; 1: 2.5), total N and P according to standard procedures (Okalebo *et al*., 2002.

TABLE 1: Treatment Combination and Description

Treatment combination	Description	Treatment combination	Description
N0P0	0 Kg N/ha, 0 Kg P_2O_5/ha (Control)	N2P0	80 Kg N /ha, 0 Kg P_2O_5/ha
N0P1	0 Kg N/ha, 50 Kg P_2O_5/ha	N2P1	80 Kg N /ha, 50 Kg P_2O_5/ha
N0P2	0 Kg N/ha, 100 Kg P_2O_5/ha	N2P2	80 Kg N /ha, 100 Kg P_2O_5/ha
N1P0	40 Kg N/ha, 0 Kg P_2O_5/ha	N3P0	120 Kg N /ha, 0 Kg P_2O_5/ha
N1P1	40 Kg N/ha, 50 Kg P_2O_5/ha	N3P1	120 Kg N /ha, 50 Kg P_2O_5/ha
N1P2	40 Kg N/ha, 100 Kg P_2O_5/ha	N3P2	120 Kg N /ha, 100 Kg P_2O_5/ha

At 6 weeks after planting (WAP), leaf samples were collected by cutting using a sharp sterilized knife from the three central watermelon plants, oven-dried at 80ºC for 48 hours and grounded. The mineral constituents of the plant were determined by digesting the samples on a labcon digester at 300°C in a mixture of hydrogen peroxide, sulphuric acid, selenium and salicyclic acid (Okalebo *et al.*, 2002). The digests were analyzed for total N and P. The total N content in the digests were determined by Kjeltec method using FOSS instrument as described in the ASN3201 as total Kjeldahl nitrogen (TKN). Total phosphorous was determined using the ascorbic acid blue colour procedure and the absorbance measured at 880 nm wavelength UV-spectrophotometer (Okalebo *et al*., 2002).
The field was ploughed and harrowed once before planting on the flats in April 2012 and February 2013. Two seeds were planted per hill with a spacing of 1.5×0.6m. The seedlings were later thinned to one per hill two weeks after sowing to give 21 plants per sub-plot. Two weeding were carried out manually using hand hoe at four & eight weeks after planting respectively. At four weeks after sowing the crops were sprayed three times with lamdacyahalothrin ‘Karate’ (insecticide) and benomyl (benlate) fungicide at the rates of 2 liters and 1.5kg/ha respectively at Four, six and eight Weeks After Planting (WAP) to protect the plants against insect pests and fungal. Records for each of the 3 central watermelons per each sub-plot treatment were taken on the plant attributes including: days to flowering, sex-expression ratio. Ten weeks after planting (WAP) records were also taken on the following plant attributes: fruit number/plant, fruit weight[kg]/plant using a weighing balance, rind thickness [cm] using a ruler, total soluble solids by use of a refractometer using flesh near the center of the 3 central watermelon in each sub-plot and firmness using a penotrometer. Petiole analysis for N and P was done at early fruit set, fruit ½ sizes and at first harvest. The data collected for each season were subjected to Analysis of Variance (ANOVA) and means separated using the THSD at P=0.05 and experiment was repeated twice.

RESULTS

Interaction Effects of Nitrogen and Phosphorus Levels on Yield Components and Yield of Watermelon

a) Days to Flowering

Nitrogen and P levels had significant interaction effects on watermelon days to flowering (Table 2). The treatment combination of 40 Kg N/ha and 50 Kg P_2O_5/ha and 40 Kg N/ha 100 Kg P_2O_5/ha had the first flowers to appear while the last flowers to appear were recorded when P was applied at the level of 0 Kg P_2O_5/ha. When N was applied at 80 Kg N/ha and Phosphorus applied at 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha had the first flowers to appear while the last flowers to appear were observed under P levels 0 Kg P_2O_5/ha. Application of N levels at 40 Kg N/ha and when Phosphorus was applied at the rate of 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha had the first flowers to appear while the last flowers to appear were recorded when P was applied at the level of 0 Kg P_2O_5/ha In season1, when N was applied at 120 Kg N/ha and Phosphorus applied at 50 Kg P_2O_5/ha and 0 Kg P_2O_5/ha there was no significant difference on the days to flowering but at 0 Kg P_2O_5/ha and 100 Kg P_2O_5/ha had significant difference with 100 Kg P_2O_5/ha having the lowest days to flower and 0 Kg P_2O_5/ha the highest. In seasson2, when N was applied at 120 Kg N/ha there was no significant difference between any applied P level.

b) Sex Expression Ratio

No significant interaction effects between N and P levels were observed on the sex expression ratio in both seasons but sex expression ratio decreased with increasing interaction levels.

c) Fruit Number per Plant

Nitrogen and P levels had significant interaction effect on watermelon fruit (Table 1).In both seasons the highest fruit number was observed between N and P levels at 120 Kg N/ha and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha while the lowest was observed under the control 0 Kg P_2O_5/ha. When N was applied at 80 Kg N/ha in combination with P levels at 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha recorded the highest fruit number compared to P levels at 0 Kg P_2O_5/ha which had the lowest. There was no significant difference when N levels were applied at 40 Kg N/ha and P levels at any level. In season 1 N applied at (0 Kg N/ha) had no significant difference with P applied at any level. In season 2, N applied at (0 Kg N/ha) and P levels at 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha recorded the highest fruit number while P applied at 0 Kg P_2O_5/ha had the lowest.

d) Unit Fruit Weight

Nitrogen and P levels had significant interaction effect on watermelon unit fruit weight (Table1). In both seasons, the highest unit fruit weight was observed between N and P levels at 120 Kg N/ha and 50 and 100 Kg P_2O_5/ha while the lowest was observed at P levels of 0 Kg P_2O_5/ha. When N was applied at 80 Kg N/ha and P levels at 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha highest unit fruit weight was recorded compared to 0 Kg P_2O_5/ha levels. The highest unit fruit weight was recorded at N levels 40 Kg N/ha and

P levels at 50 and 100 Kg P_2O_5/ha compared to 0 Kg P_2O_5/ha. In season1, N application levels at 0 Kg N/ha and P levels at 100 Kg P_2O_5/ha had the highest unit fruit weight followed by50 Kg P_2O_5/ha then 0 Kg P_2O_5/ha. In season 2, N levels applied at 0 Kg N/ha and P levels applied at50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha had the highest unit fruit weight compared to 0 Kg P_2O_5/ha.

e) Yield (t/ha)

Nitrogen and P levels had significant interaction effect on watermelon yield (Table 1). In both seasons, the highest yield weight was recorded between N and P levels at 120 Kg N/ha and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha while the lowest was obtained under the control 0 Kg P_2O_5/ha. When N was applied at 80 Kg N/ha and P levels at 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha, the highest yield weight was recorded compared to 0 Kg P_2O_5/ha. Application rate of N at 80 Kg N/ha and P levels at 50 Kg P_2O_5/ha and 100 Kg P_2O_5 ha had the highest yield weight while P levels at0 Kg P_2O_5/ha recorded the lowest. Yield weight was higher at N rates of 40 Kg N/ha and P levels at 50 Kg P_2O_5/ha and 100 Kg P_2O_5 compared to 0 Kg P_2O_5/ha. In season 1 N levels applied at 0 Kg N/ha and P levels 100 Kg P_2O_5 had the highest yield weight followed by 50 Kg P_2O_5/ha then 0 Kg P_2O_5/ha. In season 2, combination of N levels at 0 Kg N/ha and P levels at50 and 100 Kg P_2O_5 had the highest yield weight while 0 Kg P_2O_5/ha had the lowest.

TABLE 2. Interaction Effects of Nitrogen and Phosphorus Levels on Yield components and Yield of Watermelon Plants during Production in Season 1 (April to Aug. 2012)

N and P interaction	Days to Flowering (days)	Sex Expression Ratio	Fruit (no./plant)	Unit Fruit weight (Kg)	Yield (t/ha)
N0P0	34.6 a*	8.30**	1.00 e*	1.28 h*	14.17 h*
N40P0	32.4 c	6.29	1.00 e	1.65 e	18.36 e
N80P0	30.0 e	6.34	1.44 cd	2.26 d	25.13 d
N120P0	28.7 g	4.24	3.20 b	2.64 b	29.33 b
N0P50	33.4 b	7.12	1.00 e	1.47 g	16.37 g
N40P50	31.4 d	6.37	1.00 e	2.27 d	25.20 d
N80P50	29.3 f	7.52	1.67 c	2.54 c	28.22 c
N120P50	28.3 gh	3.87	4.53 a	2.91 a	32.36 a
N0P100	33.4 b	7.12	1.00 e	1.56 f	17.31 f
N40P100	31.4 d	6.58	1.22 de	2.27 d	25.21 d
N80P100	29.3 f	5.60	1.67 c	2.54 c	28.22 c
N120P100	28.1 h	4.10	4.78 a	2.90 a	32.25 a

Where; N0P0-0 Kg N/ha, 0 Kg P_2O_5/ha (Control); N0P1- 0 Kg N/ha, 50 Kg P_2O_5/ha; N0P2-0 Kg N/ha, 100 Kg P_2O_5/ha; N1P0-40 Kg N/ha, 0 Kg P_2O_5/ha; N1P1-40 Kg N/ha, 50 Kg P_2O_5/ha; N1P2-40 Kg N/ha, 100 Kg P_2O_5/ha; N2P0-80 Kg N /ha, 0 Kg P_2O_5/ha; N2P1-80 Kg N /ha, 50 Kg P_2O_5/ha; N2P2-80 Kg N /ha, 100 Kg P_2O_5/ha; N3P0-120 Kg N /ha, 0 Kg P_2O_5/ha; N3P1-120 Kg N /ha, 50 Kg P_2O_5/ha; N3P2-120 Kg N /ha, 100 Kg P_2O_5/ha.

TABLE 2. Interaction Effects of Nitrogen and Phosphorus Levels on Yield components and Yield of Watermelon Plants during Production in Season 2 (Feb. to Jun. 2013)

N and P interaction	Days to Flowering (days)	Sex Expression Ratio	Fruit (no./plant)	Unit Fruit weight (Kg)	Yield (t/ha)
N0P0	33.8 a*	8.88**	1.56 g*	1.48 h*	16.40 h*
N40P0	31.7 c	8.54	2.00 e	1.85 f	20.56 f
N80P0	29.9 e	8.17	2.56 d	2.46 d	27.37 d
N120P0	28.1 g	5.05	4.20 b	2.81 b	31.21 b
N0P50	32.7 b	10.62	1.89 ef	1.67 g	18.59 g
N40P50	30.9 d	9.33	2.11 e	2.33 e	25.80 e
N80P50	28.9 f	7.62	3.00 c	2.73 c	30.47 c
N120P50	27.8 g	4.27	5.33 a	3.11 a	34.56 a
N0P100	32.7 b	10.24	1.89 ef	1.69 g	18.68 g
N40P100	30.8 d	12.46	2.22 de	2.33 e	25.80 e
N80P100	28.8 f	9.61	3.00 c	2.74 c	30.43 c
N120P100	27.6 g	4.63	5.22 a	3.10 a	34.45 a

Where; N0P0-0 Kg N/ha, 0 Kg P_2O_5/ha (Control); N0P1- 0 Kg N/ha, 50 Kg P_2O_5/ha; N0P2-0 Kg N/ha, 100 Kg P_2O_5/ha; N1P0-40 Kg N/ha, 0 Kg P_2O_5/ha; N1P1-40 Kg N/ha, 50 Kg P_2O_5/ha; N1P2-40 Kg N/ha, 100 Kg P_2O_5/ha; N2P0-80 Kg N /ha, 0 Kg P_2O_5/ha; N2P1-80 Kg N /ha, 50 Kg P_2O_5/ha; N2P2-80 Kg N /ha, 100 Kg P_2O_5/ha; N3P0-120 Kg N /ha, 0 Kg P_2O_5/ha; N3P1-120 Kg N /ha, 50 Kg P_2O_5/ha; N3P2-120 Kg N /ha, 100 Kg P_2O_5/ha.

*Interaction means followed by the same letter within a parameter are not significantly different (P=0.05) according to the Tukey's honestly significance difference.

**Interaction means with no letter within a parameter are not significantly different (P=0.05) at F test.

Interaction Effects of Nitrogen and Phosphorus Levels on Watermelon Fruit Quality at Harvest

a) **Rind Thickness**

Nitrogen and P levels had significant interaction effect on watermelon rind thickness. (Table 2). In both seasons, thinner rind was recorded between N and P levels at 120 Kg N/ha and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha while the thickest was obtained from fruit under the control 0 Kg P_2O_5/ha. Application of N and P levels at 80 Kg N/ha and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha recorded thinner rind while the thickest was obtained at P rate 0 Kg P_2O_5/ha. When N levels was applied at 40 Kg N/ha, P levels at50 and 100 Kg P_2O_5/ha thinner rind was observed compared to 0 Kg P_2O_5/ha which recorded the thickest. Application of N rate at 0 Kg N/ha in combination with P levels at50 and 100 Kg P_2O_5/ha resulted to a thinner rind while the thickest was obtained at P rate 0 Kg P_2O_5/ha.

b) Total Soluble Solids

Nitrogen and P levels had significant interaction effect on TSS of watermelon fruits (Table 2).In both seasons, higher TSS was recorded between N and P levels at 120 Kg N/ha and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha while the lowest TSS was recorded from fruit under the control 0 Kg P_2O_5/ha. N at 80 Kg N/ha and P levels at 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha recorded the highest TSS compared to P levels at 0 Kg P_2O_5/ha. TSS was higher when N levels was applied at 40 Kg N/ha and P levels at50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha compared to 0 Kg P_2O_5/ha. Application of N at 0 Kg N/ha and P levels and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha recorded the highest TSS compared to P levels at 0 Kg P_2O_5/ha.

TABLE 2. Interaction Effects of Nitrogen and Phosphorus Levels on Quality at Harvest of Watermelon Fruit during Production in Season 1 (April to Aug. 2012).

N and P interaction	Rind thickness (cm)	Total soluble solids (°Brix)	Fruit Firmness (KgF)
N0P0	0.99 a*	7.8 g*	2.8 g
N40P0	0.89 b	10.0 e	4.3 e
N80P0	0.73 d	11.1 c	6.0 d
N120P0	0.57 e	11.7 b	7.6 b
N0P50	0.93 b	9.4 f	3.9 f
N40P50	0.82 c	11.0 cd	5.6 e
N80P50	0.61 e	11.7 b	7.2 c
N120P50	0.40 f	12.7 a	8.9 a
N0P100	0.93 b	9.5 f	3.8 f
N40P100	0.80 c	10.9 d	5.5 e
N80P100	0.60 e	11.6 b	7.1 c
N120P100	0.43 f	12.6 a	8.8 a

Where; N0P0-0 Kg N/ha, 0 Kg P_2O_5/ha (Control); N0P1- 0 Kg N/ha, 50 Kg P_2O_5/ha; N0P2-0 Kg N/ha, 100 Kg P_2O_5/ha; N1P0-40 Kg N/ha, 0 Kg P_2O_5/ha; N1P1-40 Kg N/ha, 50 Kg P_2O_5/ha; N1P2-40 Kg N/ha, 100 Kg P_2O_5/ha; N2P0-80 Kg N /ha, 0 Kg P_2O_5/ha; N2P1-80 Kg N /ha, 50 Kg P_2O_5/ha; N2P2-80 Kg N /ha, 100 Kg P_2O_5/ha; N3P0-120 Kg N /ha, 0 Kg P_2O_5/ha; N3P1-120 Kg N /ha, 50 Kg P_2O_5/ha, N3P2-120 Kg N /ha, 100 Kg P_2O_5/ha.

*Interaction means followed by the same letter within a parameter are not significantly different (P=0.05) according to the Tukey's honestly significance difference.

TABLE 2. Interaction Effects of Nitrogen and Phosphorus Levels on Quality at Harvest of Watermelon Fruit during Production in Season 2 (Feb. to Jun. 2013)

N and P interaction	Rind thickness (cm)	Total soluble solids (°Brix)	Fruit Firmness (KgF)
N0P0	1.09 a*	7.9 g*	3.0 h*
N40P0	0.99 b	10.2 e	4.5 f
N80P0	0.83 d	11.3 c	6.2 d
N120P0	0.67 e	11.9 b	7.8 b
N0P50	1.03 b	9.7 f	4.1 g
N40P50	0.92 c	11.2 cd	5.8 e
N80P50	0.71 e	11.9 b	7.2 c
N120P50	0.50 f	12.9 a	9.1 a
N0P100	1.03 b	9.7 f	4.0 g
N40P100	0.90 c	11.1 d	5.7 e
N80P100	0.70 e	11.8 b	7.3 c
N120P100	0.53 f	12.9 a	9.0 a

Where; N0P0-0 Kg N/ha, 0 Kg P_2O_5/ha (Control); N0P1- 0 Kg N/ha, 50 Kg P_2O_5/ha; N0P2-0 Kg N/ha, 100 Kg P_2O_5/ha; N1P0-40 Kg N/ha, 0 Kg P_2O_5/ha; N1P1-40 Kg N/ha, 50 Kg P_2O_5/ha; N1P2-40 Kg N/ha, 100 Kg P_2O_5/ha; N2P0-80 Kg N /ha, 0 Kg P_2O_5/ha; N2P1-80 Kg N /ha, 50 Kg P_2O_5/ha; N2P2-80 Kg N /ha, 100 Kg P_2O_5/ha; N3P0-120 Kg N /ha, 0 Kg P_2O_5/ha; N3P1-120 Kg N /ha, Kg N/ha; N3P2-120 Kg N /ha, 100 Kg P_2O_5/ha.

*Interaction means followed by the same letter within a parameter are not significantly different (P=0.05) according to the Tukey's honestly significance difference

c) Fruit Firmness

Nitrogen and P levels had significant interaction effect on watermelon fruit firmness (Table2). In both seasons, higher fruit firmness was recorded between N and P levels at 120 Kg N/ha and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha while the lowest fruit firmness was recorded under the control 0 Kg P_2O_5/ha. At 80 Kg N/ha and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha the highest firmness was recorded while the lowest was obtained at P rate 0 Kg P_2O_5/ha. At 40kgN/ha and when P was applied at 50 Kg P_2O_5/ha and100kg P_2O_5/ha had the highest fruit firmness compared to similar N treatment and when P was applied at 0 Kg P_2O_5/ha. At 0 Kg N/ha and 50 Kg P_2O_5/ha and 100 Kg P_2O_5/ha the highest firmness was recorded while the lowest was obtained at P rate 0 Kg P_2O_5/ha

Interaction Effects of Nitrogen and Phosphorus Levels on Tissue Analysis during Watermelon Production

The results from watermelon leaf tissue (petiole) analysis indicated that there was no significant difference in total nitrogen and phosphorous in all interactions in both seasons. However, higher total nitrogen was observed at interaction120 Kg N/ha and100kg P_2O_5/ha and lowest at 0 Kg N/ha and 0 Kg P_2O_5/ha in season. 1n season 2 higher total nitrogen was observed at interaction 80 Kg N/ha and 50 kg P_2O_5/ha and lowest at 0 Kg N/ha and100 Kg P_2O_5/ha. Higher total phosphorus was observed at interaction40 Kg N/ha and lowest at 0 Kg N/ha and 0 Kg P_2O_5/ha in season1. In season 2 Higher total phosphorus was observed at interaction 40 Kg N/ha and100 Kg P_2O_5/ha while the lowest was observed at0 Kg N/ha. In general, nitrogen and phosphorous content on watermelon leaves increased with increasing interactions levels of nitrogen and phosphorus (Table3).

TABLE 3. Interaction Effects of Nitrogen and Phosphorus Levels on Tissue Analysis during Watermelon Production in season1 (April to Aug. 2012) and Season 2 (Feb. to Jun. 2013).

N and P interaction	Total Nitrogen in Leaf Petiole (%) Season 1	Available Phosphorus in Leaf Petiole (ppm	Total Nitrogen in Leaf Petiole (%) Season 2	Available Phosphorus in Leaf Petiole (ppm
N0P0	0.90	0.19	1.00	0.23
N40P0	1.36	0.26	1.38	0.24
N80P0	0.98	0.26	1.34	0.25
N120P0	1.25	0.20	1.44	0.24
N0P50	0.94	0.22	1.03	0.20
N40P50	1.40	0.25	1.38	0.25
N80P50	1.34	0.24	1.47	0.24
N120P50	1.36	0.24	1.37	0.26
N0P100	0.92	0.24	0.98	0.25
N40P100	1.34	0.23	1.46	0.27
N80P100	1.37	0.22	1.43	0.26
N120P100	1.45	0.22	1.40	0.23

Where; N0P0-0 Kg N/ha, 0 Kg P_2O_5/ha (Control); N0P1- 0 Kg N/ha, 50 Kg P_2O_5/ha; N0P2-0 Kg N/ha, 100 Kg P_2O_5/ha; N1P0-40 Kg N/ha, 0 Kg P_2O_5/ha; N1P1-40 Kg N/ha, 50 Kg P_2O_5/ha; N1P2-40 Kg N/ha, 100 Kg P_2O_5/ha; N2P0-80 Kg N /ha, 0 Kg P_2O_5/ha; N2P1-80 Kg N /ha, 50 Kg P_2O_5/ha; N2P2-80 Kg N /ha, 100 Kg P_2O_5/ha; N3P0-120 Kg N /ha, 0 Kg P_2O_5/ha; N3P1-120 Kg N /ha, 50 Kg P_2O_5/ha; N3P2-120 Kg N /ha, 100 Kg P_2O_5.

DISCUSSION

Interactions of Nitrogen and phosphorus had significant effects on watermelon yield components and yield. Increase in interactions levels of nitrogen and phosphorus resulted in reduction in days to flowering, lower sex expression ratio, more fruits, heavier fruits and subsequently higher fruit yield. Nitrogen and Phosphorus are known to promote vegetative growth (Eifediyi and Remison, 2009). More leaves translate to better chlorophyll development and higher stomatal conductance hence enhanced photosynthesis. This therefore leads to more photosynthates being manufactured. It is therefore possible that more photosynthates were translocated to the sinks leading to earlier maturity of watermelon fruits, more and heavier fruits subsequently leading to higher yield. This is in agreement to the findings from (Eifediyi and Remison, 2009) who found out that cucumber grown in increasing levels of inorganic fertilizer (N.P.K.20:10:10) application up to the highest level revealed significant increase in the growth and yield attributes of cucumber including the vine length, number of leaves per plant, number of branches, leaf area, number of fruits per plant, fruit length, fruit girth, fruit weight per plant, fruit number per plant signifying an increase in total yield per hectare. Furthermore, this findings are collaborated by (Akanbi *et al.*, 2010) who found out that *Solanum melongena var.'* long purple', grown in increasing levels of NPK (15:15:15) application revealed significant increase in growth parameters and fruit traits of brinjols including fruit and seed attributes such as length, girth, number of fruits /plant, number of seeds/fruits, seed weight and fruit yield. The number of fruits/plant ranged from 4.3 in non-fertilized plants to 8.2 in 300 NPK Kg/ha treatment signifying an increase in total yield per hectare. In both phenomenon above (brinjols and cucumber) increasing rates of NPK resulted to simultaneous increase in P and N uptake resulting to better interaction at higher levels thus better growth parameters and yield attributes.

The decline in yield at high interaction levels of N and P rates could be explained by the fact that a high concentration of soluble N increases the osmotic potential of the soil solution, causing reduction in water uptake by the plant roots (Onyango, 2002). According to Agba and Enya (2005) excess nitrogen application causes osmotic stress, which can cause oxidative damage injuring many important cellular components, such as lipids, protein, DNA and RNA leading to reduced growth and eventual yield of plants. However, (Eifediyi and Remison, 2009) reported that further increases in nitrogen enhance growth and yield, which could be attributed to the fact that plants have the ability to take up N that is not necessarily transformed into dry matter and hence growth. Nitrates absorbed by the plants are normally assimilated in the roots into nitrites then to ammonium and amino acids through the action of nitrate and nitrite reductase enzymes (Marschner, 1995) and not all absorbed nitrate ions are reduced and converted into amino acids but are stored in the plant cells as nitrates (Onyango, 2003) as influenced by plant nitrogen use efficiency and the amount applied (Eifediyi and Remison, 2009). The watermelon sex ratio significantly increased with increase in interaction of nitrogen and phosphorous up to a point (more than 80 Kgs N/Ha and100 Kg P_2O_5/ha) when further increase led to a reduction. This is in agreement to the findings from Agba and Enya (2005) who found out that cucumber grown in increasing levels of nitrogen fertilizers lead to a significant decrease in their sex ratio signifying an increase in female flowers. The decreasing sex ratio leads to a greater potential fruit yield because of the increase in the number of female flowers per plant which develops into fruits (Grunes, 1959) reported complimentary action of the two elements P & N hence as nitrogen was increasing soil available phosphorous uptake was increasing hence supporting sufficient interaction leading to reduction in sex ratio. Interactions of nitrogen and phosphorus fertilizers significantly influenced quality of watermelon fruits at harvest. Quality of the fruit was enhanced with interaction increase in nitrogen and phosphorus levels. Quantitative analysis revealed the influence of Nitrogen and Phosphorus interaction in determining the watermelon quality. This was confirmed through the fruits which were more firm, thinner rind, with significantly increased total soluble solids (TSS) and low acidity as compared to control treatments. These results are in agreement with Aguyoh *et.al* 2010 who reported that increased nutrient application enhances the quality of watermelon fruits. Furthermore Nitrogen and phosphorous helps in starch formation which during ripening is converted to sugar. Nitrogen and Magnesium are integral part of chlorophyll molecule and at higher level they supported the intake of K, hence resulted in the enhanced sweetness of watermelon fruits (Table 2). Chloroplast contain protein rich in sulphur, manganese maintain chloroplast structure of stroma and grana and at higher interaction level of N and P their uptake was supported along with water uptake. This resulted to stable chloroplast hence increased chlorophyll content thus higher net photosynthesis leading to increased TSS in the fruits. Nitrogen and phosphorus plays a role in photosynthesis and at higher interaction levels activated potassium and calcium uptake which are responsible for transporting photosynthates from source (leaves) to the sinks (fruits). This enhanced transport led to a good quality fruits with higher TSS, thinner rind thickness and firmer. Phosphorus plays a major role during root development which enhances uptake of nitrogen, water and other nutrients. Water helps in cell wall and membrane development. It is therefore possible that higher interaction levels of nitrogen and phosphorus would have led to higher total soluble solids and firmer fruits. Phosphorus on the other hand helps in root development. Better developed roots enhances uptake of water, and calcium among other minerals. Water and calcium have been reported to play a major role in cell wall development. Calcium plays an important role in maintaining the quality of fruits and vegetables (Gichimu *et al.*, 2008). Calcium may have two opposite effects on texture. Calcium firms the tissue via complexed formation with pectic substances; in addition, it enhances tissue softening by β -elimination. However, the net result of calcium addition has invariably been to firm the tissue of fruits (Agba and Enya, 2005). This may therefore be attributed to less TA, higher TSS, and firmer fruits due to phosphorus application which are important qualities on watermelon. The interaction of N and P at high level improved sugar content compared to zero interaction .The improved crop growth in response to better interaction of N and P application led to higher rate of photosynthesis and therefore higher amount of sugar in the fruit. Interaction of N and P at high levels resulted to optimal stomatal conductance. This lead to efficient carbondioxide assimilation and water use efficiency hence higher photosynthesis and therefore higher sugars in the fruits. Manganese activates several enzymes and is involved in the processes of electron transport system in photosynthesis. Interaction of N& P at high levels supported manganese uptake leading to enhanced electron transport system hence higher net photosynthesis thus increased TSS in the fruits. Similar results were observed when compound fertilizer applied at different levels was used in Kenya {NPK (16:16:8)}. Use of compound fertilizer resulted to watermelon fruits with higher total soluble solids and more firm fruits compared with the control (Gichimu *et al.*, 2008).

Interaction of nitrogen and phosphorus influenced availability of nitrogen and phosphorus on both soil and watermelon tissue. Nitrogen and phosphorus availability increased with increasing interaction levels of nitrogen and phosphorus. Calcium ammonium nitrate fertilizers contain calcium ions, this in turn displaces Hydrogen ions in soil solution to adsorption sites resulting into a PH range that favours both N and P availability in the soil, hence increase in nitrogen and phosphorus interaction rates resulted in increase in P and N availability both in soil and leaves (petioles). Agba and Enya (2005) found sufficient ranges of recently matured watermelon leaf petiole when nutrient was applied as compound fertilizer (NPK). Therefore, the nutrient uptake of nitrogen and phosphorus was sufficient.

CONCLUSION & RECOMMENDATION

Interaction of nitrogen and phosphorus fertilizers levels influenced growth, yield and quality of watermelon. Interaction of N and P significantly led to more fruits, more female flowers and subsequently higher yield. Quality of watermelon fruits was also significantly improved with thinner rind thickness, higher TSS, and lower TA.Therefore; this provides coastal farmers with the best Interaction of nitrogen and Phosphorous fertilizer rates that may be applied in integrated nutrient management for watermelon production. Based on these findings, 50 Kg P_2O_5/ha and120KgN/ha for improved growth, yield and quality of water melons in the coastal region of Kenya was recommended.

ACKNOWLEDGEMENT

The successful completion of this work was a team effort. The authors acknowledge the Matuga research station and the Department of Crops, Horticulture and Soils, Egerton University for their support.

REFERENCES

Agba, O. A., Enya, V. E. (2005) Responses of cucumber *(Cucumis sativa* L*)* to nitrogen in Obubra, Cross River State. Global Journal of Agricultural Sciences 4(2):165-167.

Aguyoh, J.N., Audi, W., Saidi, M. and Gao-Qiong, L. (2010) Growth, Yield and Quality Response of Watermelon (*Citrullus lanatus* [Thunb] Mansf. & Nakai) Cv. Crimson Sweet) Subjected to Different Levels of Tithonia Manure. International Journal of Science and Nature 1:7-11.

Akanbi, W.B., Olaniran, O.A., Tairu, F.M., Akinfasoye, J. A., Ojo, M.A., Adeyeye, A.S. & Ilupeju, E.A.O. (2010) Response of Solanum Melongena to NPK Fertilizer and Age of Transplant in the Guinea Savana Zone of Ecological Area of South Western Nigeria. Libyan Agriculture Research Center Journal Internation 1:202-210.

Eifediyi, E.K. & Remison, S.U. (2009) The Effects of Inorganic Fertilizer on the Yield of Two Varieties of Cucumber (*Cucumis sativus* L.). Report and Opinion, 1:74-80.

Food and Agriculture Organization (2007) Crop Water management-Watermelon. Land and Water Management Division. 145pp.

Gichimu, B.M., Owuor, B.O. and Dida, M.M. (2008) Agronomic Performance of Three Most Popular Commercial Watermelon Cultivars in Kenya as Compared to One Newly Introduced Cultivar and One Local Landrace Grown on Dystric Nitisols under Sub-Humid Tropical Conditions. ARPN Journal of Agricultural and Biological Science. 3:65-71.

Grunes, D.L. (1959) Effect *of* nitrogen *on* phosphorus availability *In* A.G. Norman *(*ed*.),* Advances *in* agronomy, Vol. 11. Academic Press, New York, pp. 369– 396.

Goreta, S., S. Perica G. Dumicic, Bucan, L. and Zanic, K. (2005) Growth and Yield of Watermelon on Polyethylene Mulch with Different Spacings and Nitrogen Rates. American Journal of Hortultural Science. 40(2): 366-369

HCDA. (2006) Fruits and Vegetables. Horticultural Crops Development Authority Technical bulletin.

Huh, Y.C., Solmaz, I. and Sari, N. (2008) Morphological characterization of Korean and Turkish watermelon germplasm 1 Cucurbitaceae 2008, Proceedings of the IXth EUCARPIA meeting on genetics and breeding of Cucurbitaceae (Pitrat M. ed.), INRA, Avignon (France). May 21-24.

Kanyanjua, S.M., Keter, J.K., Okalebo, R.J. and Verchot, L. (2006) Identifying Potassium-Deficit Soils in Kenya By Mapping and Analysis of Selected Sites. Soil Science 171(8):610-625.

Ministry of Agriculture (2003) Fruits and Vegetables. Agricultural Resource Center, Nairobi, Kenya. 120 pp.

Okalebo, J.R., Gathua, K.W. and Woomer, P.L. (2002) Laboratory methods of soil and plant analysis: A working manual. TSBF: Nairobi, Kenya.

Onyango, M.A. (2002) Effect of nitrogen on leaf size and anatomy in onion (*Allium cepa* L.). East African Agriculture and Forestry Journal. 68(2):73 - 78.

Tindall, H.D. (1983) Vegetables in the tropics. The Macmillan press Ltd., London. pp. 150-152.

Zohary, D. & Hopf, M. (2000) Domestication of Plants in the Old World. 3rd Ed. Oxford University Press