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PRODUCTION OF MINERAL NUTRIENT-RICH MULTIPURPOSE PUMPKIN LEAFY VEGETABLESUSING INTEGRATED RESOURCE MANAGEMENT

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ABSTRACT
Enhancing mineral nutrient composition in multipurpose pumpkin (*Cucurbita moschata* Duch.) is important since it contributes to household food security. To respond to this need, an experiment arranged in split-plot in randomized complete block design and replicated three times was conducted at Chuka University for two seasons from January 2019 to July 2020. The main plots were assigned to nitrogen (CAN) (0, 50, 100 and 150 kg N/ha), sub-plots to mulch (no mulch, black-painted and unpainted rice straws), while split-plots to gibberellic acid (GA_3) (0 mg/L, 40 mg/L and 80 mg/L). Nitrogen for each rate was applied in two equal doses at three weeks post-emergence and at the beginning of flowering. The black-painted and unpainted rice straws were placed on plots after land preparation. The GA_3 solution was sprayed onto plants using a knapsack sprayer, starting with 40 mg/L followed by 80 mg/L, once during the fourth week after emergence. Data collection was done fortnightly from the fourth week after emergence and data values were subjected to analysis of variance using SAS software. Means were separated using the least significant difference test at α=0.05. Highest levels of potassium and magnesium were obtained for 100 kg N/ha. On the other hand, phosphorus and beta-carotene were highest in treatments where unpainted rice straw mulch was used, while application of 80 mg/L of GA_3 gave high phosphorus and potassium contents. Results further showed that combined N fertilizer, mulch and GA_3 had a significant ($P<0.05$) effect on nitrogen, phosphorus, potassium, magnesium and beta-carotene contents during both seasons, implying that they are useful factors in evaluation of mineral nutrient contents in leaves of multi-purpose pumpkins.
Keywords: African leafy vegetables, Soil covers, Mineral nutrients, NUS

INTRODUCTION
Pumpkin (*Cucurbita moschata* Duch.) acts as a dependable source of food, providing families producing it with various diets and contributes to household food security. Pumpkins' leaves, fruits and seeds are of importance to the consumers. The nutritional value of pumpkin fruits is high, but varies depending on the species and cultivars. The flesh of pumpkins fruits is tasty and valuable vegetable containing a lot of biologically active materials and distinguished for dietary qualities (Juknevicience *et al.*, 2013). Pumpkins contain a lot of mineral materials, vitamins, particularly vitamin A provitamin β-carotene, ascorbic acid, vitamins B1, B2, B6 and E. They are rich in carbohydrates, particularly in starch and sugars. Amount of sugars in pumpkins strongly depends on

climatic conditions; average amount is 5–6%. Pumpkins have low calorific value; their energetical value fluctuates from 15 to 39 kcal (Murkovic *et al.*, 2004).

Nitrogen (N) is the most commonly required fertilizer during pumpkins production although phosphorous is needed to promote good seedling vigor, maximum production and high fruit quality (Mahfouz & sharaf-eldin, 2007). N is commonly applied in two side-dressings, the first at the 2-4 leaf stage and the second when vines start to develop runners. Excessive nitrogen favors vegetative growth over reproductive growth and can inhibit fruit set. Nitrogen rate must be low enough by the time of flowering for plants to form fewer new leaves to allow more sugars to go into fruits, rather than into developing leaves and vines (Min-gang *et al.*, 2008).

Mulches and particularly the clear form have been reported to enhance germination of direct-seeded pumpkins since they increase soil temperatures (Fang *et al.*, 2011). Fang *et al.* (2011) reported that as a result of mulching with grass over 55% of the available nitrogen was released to the soil during the first 4 months of application during pumpkins production. Yamaguch and Kamiya (2000) reported that gibberellin hormone plays an essential role in many aspects of growth and development of pumpkins such as seed germination, stem elongation and flower development. GA_3 delays senescence, improves growth and development of chloroplasts and intensifies photosynthetic efficiency which could lead to increased yield (Yuan & Xu, 2001). The objective of this study was to determine the effect of N fertilizer, mulch and GA_3 on the mineral composition in the leaves of multi-purpose pumpkins.

MATERIALS AND METHODS

The experiment was conducted at Chuka University Ndagani research farm. The farm lies at 0^0 19' S, 37^0 38’ E and 1535 m above sea level. The average annual temperature is 19.5 ºC (from 12.2 ºC and 23.2 ºC). The area experiences two rainy seasons with the long rainy season occurring in March through June and the short rainy season from October to December. The average annual rainfall is 1200 mm annually (http://en.climate-data.org). The soils are humic Nitisols, deep, strongly weathered, well drained tropical soils with a clayey subsurface horizon made of angular, blocky structural elements that easily crumble into polyhedricipeds with shiny faces. The soil hasa high cation exchange capacity (Koskey *et al.*, 2017).

A three factor split-split block experiment embedded in a randomized complete block design (RCBD) with three replications was used. Individual plots in a block measured 2m x 2m separated from each other by 1 m. The three factors were four nitrogen rates, three mulch types and three gibberellic acid (GA) rates. Nitrogen occupied the main plot; mulch the split plots and gibberellic acid the subplots. The four nitrogen rates were 0, 50, 100 and 150 kg/ha. Nitrogen in CAN was applied in two split equal dosages for each rate, at three weeks post-emergence and at the beginning of flowering. Single fertilizers were used. The mulch factor included no mulch, black-painted rice straw and unpainted rice straw. Rice straw was easily available in a close proximity to experimental site and quantities required were easy to get. The black-painted dry rice straw and unpainted dry rice straw was placed on the respective split plots after land preparation. Painting of the rice straw was done by dipping them in a 200 L drum containing the black paint solution and afterwards spread out to air dry. The ingredients of the paint were noted based on the paint that was used. The mulch was uniformly spread to achieve 20 cm thickness. Planting holes were marked and opened during sowing.

Gibberellic acid rates were 0 mg/L 40 mg/L and 80 mg/L. Gibberellic acid was dissolved in 50ml alcohol then the volume was made up to one liter stock solution by adding distilled water. The required concentration of spray solution was then prepared from stock solution by diluting with distilled water. A few drops of acceptable commercial sticker was added to solutions to facilitate the uptake of the GA. The gibberellic acid solution was sprayed to the plants with a hand sprayer of one liter capacity. Stock solution of lower rate was sprayed first followed by next higher rate. It was done once during the fourth week after emergence. To avoid drift, spraying was done in a calm morning.

Soil analysis was done before plant establishment. It was done at the KALRO National Laboratories at Kabete. Testing was done to establish the nutrient levels which informed the effects of applied nitrogen. The soil was sampled using a zigzag sampling pattern across the experimental field. A soil auger and plastic containers were used for two different composite samples, taken from 0-15 cm and 16-30 cm, respectively. Soil pH, total N, available P, K, Ca, Mg, organic carbon, and trace elements were assessed (Chang & Laird, 2002).

Data was collected for two seasons (long and short rain seasons). Sample leaf vegetables were cleaned with water and rinsed with distilled water to avoid surface contamination according to Ahmed *et al.* (2008). The leaves samples (2 leaves) were similarly oven dried at 60º C until a constant weight was achieved. The samples were then crushed to a fine powder using mortar and pestle, sieved through 20-mesh and stored in an air tight plastic container for analysis. The sample was then digested into solution by wet digestion using a mixture of conc. Nitric, perchloric and sulphuric acids in the ratio 9:2:1 respectively. Nitrogen in the vegetable leaves was determined based on the Kjeldhal procedure. Magnesium was determined by Fourier transform Infrared Spectrophotometry, potassium was determined using atomic emission spectrometer while colorimetric method was used to determine phosphorus according to the procedures described by AOAC (1990). Data values were subjected to analysis of variance to determine effects of the treatments using the SAS software version 9.3. Means separation was performed using the least significant difference (LSD) test at $\alpha = 0.05$.

RESULTS

Effect of nitrogen on nitrogen, phosphorus, potassium, magnesium and beta-carotene

Nitrogen had a significant (P<0.05) effect on nitrogen content in leaf tissue (Table 1). Application of 150 kg N/ha produced the highest nitrogen of 2.88 ppm and 2.95 ppm in S1 and S2, respectively. Nitrogen content increased with increase in nitrogen rate in that application of 150kg N/ha yielded the highest nitrogen content. Nitrogen had a significant (P<0.05) effect on phosphorus content in both seasons. Application of 50 kg N/ha produced the highest phosphorus content of 219.26 ppm and 217.91 ppm in S1 and S2, respectively. Lowest phosphorus content resulted when 150 kg N/ha was applied, since pumpkin leaf vegetables yielded 197.65 ppm and 197.33 ppm during S1 and S2, respectively.

Nitrogen had a significant (P<0.05) effect on the potassium content in both seasons. Application of 100 kg N/ha produced the highest potassium content of 387.3 ppm and 502.3 ppm in S1 and S2, respectively (Table 1). Potassium content increased with increase in nitrogen rate up to 100 kg N/ha in both seasons. The control treatment had potassium content of 293.7 ppm and 295.3 ppm during S1 and S2, respectively. Results also showed that nitrogen had a significant (P<0.05) effect on magnesium in pumpkin leaf vegetables during both seasons. The 100 kg N/ha treatment produced the highest magnesium content of 113.42 ppm and 114.15 ppm in S1 and S2, respectively. On the other hand, when 150 kg N/ha was applied magnesium content was lowest during both seasons.

Nitrogen had a significant (P<0.05) effect on beta-carotene during both seasons. The control treatment produced the highest beta-carotene of 9.91 ppm and 9.87 ppm in S1 and S2, respectively. Beta-carotene content decreased with increase in nitrogen rate up to 100 kg N/ha during both seasons.

Effect of mulch on nitrogen, phosphorus, potassium, magnesium and beta-carotene

Mulch had a significant (P<0.05) effect on nitrogen content in leaves during both seasons (Table 2). No mulch produced the highest nitrogen content of 1.83 ppm and 1.94 ppm in S1 and S2, respectively. Nitrogen content was lowest of 1.68 ppm and 1.76 ppm in S1 and S2, respectively, for unpainted rice straw mulch. Mulch had a significant (P<0.05) effect on phosphorus content in both seasons. Unpainted rice straw mulch produced the highest phosphorus content of 206.23 ppm and 206.93 ppm in S1 and S2, respectively (Table 20). Lowest phosphorus content of 200.86 ppm and 201.23 ppm in S1 and S2, respectively, was obtained for no mulch.

Mulch had a significant (P<0.05) effect on potassium content in S1 and no significant (P>0.05) effect during S2. The control treatment produced the highest potassium content of 376.8 ppm and 392.1 ppm in S1 and S2, respectively (Table 20). The unpainted rice straw mulch treatment potassium content was lowest of 292.6 ppm and
382.3 ppm during S1 and S2, respectively. Mulch also had a significant (P<0.05) effect on magnesium in leaves during both seasons (Table 2). The black-painted rice straw mulch produced the highest magnesium content of
108.95 ppm and 110.68 ppm in S1 and S2, respectively. On the other hand, the magnesium content of 106.40 ppm and 106.76 ppm in S1 and S2, respectively, was lowest for unpainted rice straw mulch.

Mulch had a significant (P<0.05) effect on beta-carotene in leaves during both seasons. The unpainted rice straw mulch treatment produced the highest beta-carotene of 8.84 ppm and 6.75 ppm in S1 and S2, respectively. Beta- carotene content of 6.03 ppm and 5.86 ppm in S1 and S2, respectively, was lowest for the control treatment. Mulching affected phosphorus, potassium, magnesium and beta-carotene contents in leaves positively.

Effect of GA_3 on nitrogen, phosphorus, potassium, magnesium and beta-carotene

Nitrogen content in leaf tissue was significantly (P<0.05) affected by GA_3 during both seasons (Table 3). Application of 40 mg/L GA_3 produced the highest leaf nitrogen content of 1.87 ppm and 1.94 ppm during S1 and S2, respectively. Leaf nitrogen content was lowest of 1.71 ppm and 1.73 ppm in S1 and S2, respectively, when 80 mg/L GA_3 was applied. Gibberellic acid had a significant (P<0.05) effect on phosphorus in both seasons. Application of 80 mg/L GA_3 yielded the highest phosphorus of 210.04 ppm and 210.55 ppm in S1 and S2, respectively. The lowest phosphorus of 192.22 ppm and 194.44 ppm during S1 and S2, respectively, was obtained under the control.

There was a significant (P<0.05) effect of GA_3 on potassium in both seasons. Application of 80 mg/L GA_3 had the highest potassium of 365.26 ppm and 419.61 ppm in S1 and S2, respectively (Table 3). For the control treatment, potassium was lowest of 302.2 ppm and 330.9 ppm in S1 and S2, respectively. Results showed that GA_3 had a significant (P<0.05) effect on Mg during both seasons. The control treatment produced the highest Mg content of 111.74 ppm and 113.24 ppm in S1 and S2, respectively. The Mg was lowest of 106.04 ppm and 105.52 ppm during S1 and S2, respectively, when 80 mg/L GA_3 was applied. Gibberellic acid had a significant (P<0.05) effect on beta- carotene in the pumpkins during both seasons. The 40 mg/L GA_3 treatment produced the highest beta-carotene of 9.93 ppm and 6.93 ppm in S1 and S2, respectively. Beta-carotene content was lowest of 5.53 ppm and 5.50 ppm during S1 and S2, respectively, when 80 mg/L GA_3 was applied.

Effect of treatments on nitrogen, phosphorus, potassium, magnesium and beta-carotene in leaves

A significant (P<0.05) effect was observed due to interaction on N content in pumpkin leaves produced during both seasons (Table 4). Highest N content of 3.26 ppm was obtained for $N_3M_1GA_0$, while lowest N content of 0.39 ppm was obtained for $N_0M_0GA_0$ during S1. During S2, highest N content of 3.32 ppm was recorded for $N_3M_1GA_1$, while lowest N content of 0.29 ppm was recorded for $N_0M_0GA_0$ during S1. The $N_3M_1GA_0$ (150kg N/ha, black-painted rice straw mulch and 0 mg/L GA_3) and $N_3M_1GA_1$ (150kg N/ha, black-painted rice straws mulch and 40 mg/L GA_3) had the highest interaction effect on nitrogen content during S1 and S2, respectively.

There was significant (P<0.05) effect of interaction on P during both seasons. The P of 299.36 ppm was highest for $N_3M_2GA_{0,}$ while the lowest P of 85.33 ppm was recorded for $N_2M_0GA_0$ in S1 (Table 40). During S2, highest P of 300.07 ppm was recorded for $N_3M_2GA_0$, while the lowest P of 87.70 ppm was recorded for $N_2M_0GA_0$. The $N_3M_2GA_0$ (150 kg N/ha, unpainted rice straw mulch and 0 mg/L GA_3) had the highest combined effect of nitrogen, mulch and GA_3 on p content in both seasons. Potassium was highest 475.7 ppm for $N_3M_0GA_1$ and lowest 172.8 ppm for $N_0M_1GA_2$ in S1. The 653.2 ppm was the highest obtained for $N_3M_1GA_{2,}$ while $N_3M_2GA_1$ had the lowest of 107.2 ppm during S2. The $N_3M_0GA_1$ (150 kg N/ha, no mulch and 40 mg/L GA_3) and $N_3M_1GA_2$ (150 kg N/ha, black- painted rice straw mulch and 80 mg/L GA_3 had the highest interaction effect on potassium in S1 and S2, respectively. There was a significant (P<0.05) effect of interaction effect on potassium in both seasons.

Highest magnesium of 131.25 ppm was for $N_2M_2GA_0$, while the lowest of 52.77 ppm was for $N_0M_2GA_2$ in S1 (Table 4). The 132.87 ppm was the highest magnesium for $N_2M_2GA_{0,}$ while $N_0M_2GA_2$ had the lowest 53.51 ppm magnesium in S2. The $N_2M_2GA_0$ (100 kg N/ha, unpainted rice straw mulch and 0 mg/L GA_3) had the highest interaction effect on magnesium in both seasons. There was a significant (P<0.05) effect of interaction on the magnesium in both seasons. There was a significant (P<0.05) effect of interaction on beta-carotene in S1 and S2. Beta-carotene of 23.16 ppm was highest for $N_1M_1GA_1$ while the lowest of 0.64 ppm was recorded for $N_2M_2GA_0$ during S1. During S2, highest Beta-carotene of 22.79 ppm was recorded for $N_1M_1GA_{1,}$ while the lowest of 0.68 ppm was recorded for $N_2M_2GA_0$. The $N_1M_1GA_1$ (50 kg N/ha, black-painted rice straw mulch and 40 mg/L GA_3) had the highest interaction effect on beta-carotene of pumpkins in both seasons.

DISCUSSION

The effect of N rates on N, P, K and Mg contents showed a significant increase as the N fertilizer increased up to 100kg N/ha (Table 1). However, the increased of the N-fertilizers level (150kg N/ha) slightly decreased N, P, K and Mg contents of pumpkins leaves compared to the intermediate, lowest levels of N applied and the control treatment. The highest significant values of the ppm of N, P, K and Mg contents were recorded with the application of 100kg N/ha. Ibrahim and Selim (2007) also found significant effect of nitrogen on N, P and K contents in the leaves of squash. Similarly, Ibrahim (1995) reported increased N, P and K percentages in squash leaves as nitrogen level applied increased up to 80 kg N /ha. El-Shabrawy (1997) observed that nitrogen in squash leaves increased as nitrogen rate increased from 60 to 120 kg N/ha, but P and K percentages were not affected by increase in nitrogen rate. High ppm of these minerals in pumpkins leaf tissues may be attributed to increased availability of nitrogen in the soil. Consequently, absorption would be higher and nutrient accumulation in leaves tissue would increase.

Nitrogen content was highest in plants which were not mulched, while plants that were mulched with unpainted rice straws had the highest phosphorous. Potassium and magnesium were highest for black-painted rice straws, while beta-carotene was highest for unpainted rice straws (Table 2). The high P, K, Mg and beta-carotene was attributed to the high uptake rate of such nutrients due to high root activity in response to high accumulation of heat in the soil which was mulched. Muhammad *et al.* (2009) reported that mulched treatments had significantly higher uptake of total N, P and K in shoots of maize compared to treatments that were un-mulched. This response was also supported by Chalker-Scott (2007), who observed that mulches are able to maintain appropriate moisture and temperature levels for easy nutrient release into the soil from where they become available for root uptake or microbial use. Torres-Olivar *et al.* (2016) found that leaf Mg and P contents were significantly affected by mulching, while K, Ca and N were not significantly affected in cucumber plants. Cruz *et al.* (2012) also reported that soil enrichment with organic matter increased beta-carotene content in lettuce leaves.

Results showed that the effect of GA_3 was significant on the N, P, K, Mg and beta carotene on the leaves of multi- purpose pumpkins (Table 3). P, K and Mg were lowest at the control treatment while N and beta carotene were lowest when 80 mg/l of GA_3 was applied. Application of plant growth regulators like GA_3 at low rates regulates growth, differentiation and development, either by promotion or inhibition of processes (Naeem *et al.*, 2004), which directly affect chemical composition of leaves. Presently, GA_3 affected N and beta-carotene negatively, while the other minerals were promoted by it. Afaf *et al.* (2007) reported that GA_3 significantly increased nitrogen and potassium contents in Globe Artichoke leaves.

Table 1: Effect of nitrogen on nitrogen, phosphorus, potassium, magnesium and beta-carotene in leaves

Nitrogen (kg/ha)	Nitrogen (ppm)		Phosphorous (ppm)		Potassium (ppm)		Magnesium (ppm)		Beta-Carotene (ppm)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
0 (Control)	0.73d	0.66d	198.02b	202.97b	293.7d	295.3d	101.99c	105.31b	9.91a	9.87a
50	1.64c	1.69c	219.26a	217.91a	302.6c	321.7c	107.98b	107.69b	9.23b	5.24c
100	1.84b	2.01b	198.38b	199.34bc	387.3a	502.3a	113.42a	114.15a	3.19d	3.20d
150	2.88a	2.95a	197.65c	197.33c	369.0b	436.1b	108.29b	107.61b	6.55c	6.52b
P-value	*0.001**	*0.001**	*0.001**	*0.001**	*0.001**	*0.001**	*0.001**	*0.002**	*0.001**	*0.001**
LSD 5%	0.121	0.089	0.358	4.983	1.198	15.05	0.988	2.989	0.068	0.073

S1= Season 1 (March 2019-July 2019); S2= Season 2 (October 2019-February 2020)
*Means followed by the same letter or no letter within a column are not significantly different according to the LSD Test at *P*= 0.05

Table 2: Effect of mulch on nitrogen, phosphorus, potassium, magnesium and beta-carotene in leaves

Mulch type	Nitrogen (ppm)		Phosphorous (ppm)		Potassium (ppm)		Magnesium (ppm)		Beta-carotene (ppm)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	1.83a	1.94a	200.86c	201.23b	376.8a	392.1	108.40a	108.63ab	6.03c	5.86c
BL	1.81a	1.79b	202.85b	205.01ab	345.0b	392.1	108.95a	110.68a	6.80b	6.02b
BR	1.68b	1.76b	206.23a	206.93a	292.6c	382.3	106.40b	106.76b	8.84a	6.75a
P-value	*0.017**	*0.017**	*0.001**	*0.018**	*0.001**	*0.098*	*0.001**	*0.023**	*0.001**	*0.001**
LSD 5%	0.102	0.125	0.281	3.793	0.534	10.26	0.801	2.681	0.034	0.043

BL= black-painted rice straw mulch; BR= unpainted rice straw mulch

S1= Season 1 (March 2019-July 2019), S2= Season 2 (October 2019-February 2020)

*Means followed by the same letter or no letter within a column are not significantly different according to the LSD Test at *P*=0.05

Table 3: Effect of GA_3 on nitrogen, phosphorus, potassium, magnesium and beta-carotene in leaves

GA_3 (mg/L)	Nitrogen (ppm)		Phosphorous (ppm)		Potassium (ppm)		Magnesium (ppm)		Beta-carotene (ppm)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
0 (Control)	1.74b	1.82b	192.22c	194.44b	302.20c	330.90b	111.74a	113.24a	6.22b	6.20b
40	1.87a	1.94a	207.72b	208.18a	346.97b	416.10a	106.39b	107.30b	9.93a	6.93a
80	1.71b	1.73c	210.04a	210.55a	365.26a	419.61a	106.04b	105.52b	5.53c	5.50c
P-value	*0.005**	*0.001**	*0.001**	*0.001**	*0.001**	*0.001**	*0.001**	*0.001**	*0.001**	*0.001**
LSD 5%	0.099	0.093	0.296	3.617	0.791	11.04	0.604	2.396	0.030	0.043

S1= Season 1 (March 2019-July2019); S2= Season 2 (October 2019-February 2020)

*Means followed by the same letter or no letter within a column are not significantly different according to the LSD Test at *P*=0.05

Table 4: Effect of treatments on nitrogen, phosphorus, potassium, magnesium and beta-carotene in leaves

Treatment	Nitrogen (ppm)		Phosphorous (ppm)		Potassium (ppm)		Magnesium (ppm)		Beta-carotene (ppm)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
$N_0M_0GA_0$	0.4	0.3	220.7	220.5	306.2	395.8	112.2	113.1	8.3	8.3
$N_0M_1GA_0$	0.6	(0.4)	174.5	180.5	292.5	294.6	112.4	117.3	4.3	4.2
$N_0M_2GA_0$	0.7	0.6	173.0	177.2	249.6	235.3	105.5	109.0	2.3	2.2
$N_0M_0GA_1$	1.1	1.4	213.0	213.3	466.2	456.5	108.8	109.2	6.3	6.3
$N_0M_1GA_1$	0.7	0.6	203.8	230.6	309.7	240.1	103.9	118.6	4.4	4.4
$N_0M_2GA_1$	0.7	0.5	165.2	167.3	243.1	218.4	109.8	112.2	4.8	5.6
$N_0M_0GA_2$	0.7	0.6	171.5	169.2	340.4	413.2	107.7	107.2	5.6	5.6
$N_0M_1GA_2$	1.3	1.1	253.2	158.3	(172.8)	217.1	104.8	107.8	8.4	8.4
$N_0M_2GA_2$	(0.4)	0.5	207.2	209.9	263.3	187.0	(52.8)	(53.5)	2.2	2.2
$N_1M_0GA_0$	1.8	1.6	291.5	290.1	299.5	272.7	107.5	107.5	3.8	3.8
$N_1M_1GA_0$	1.7	1.3	188.4	193.0	266.4	321.5	109.4	113.0	14.0	3.8
$N_1M_2GA_0$	1.3	1.2	205.3	202.2	251.9	261.0	105.7	105.0	16.1	16.0
$N_1M_0GA_1$	1.6	1.8	205.9	204.8	254.7	229.0	100.2	95.8	7.7	7.7
$N_1M_1GA_1$	1.9	2.0	203.8	197.8	306.6	369.3	104.3	102.1	**23.2**	**22.8**
$N_1M_2GA_1$	1.6	1.9	245.4	245.2	256.7	247.3	106.3	107.2	2.8	9.2
$N_1M_0GA_2$	2.0	2.3	193.0	190.2	370.1	407.0	111.3	110.6	9.0	8.9
$N_1M_1GA_2$	1.8	1.9	197.7	194.6	353.9	476.2	108.3	107.6	5.0	5.0
$N_1M_2GA_2$	1.2	1.3	242.3	243.4	363.3	311.3	119.0	120.5	1.6	1.6
$N_2M_0GA_0$	1.9	1.8	(85.3)	(87.7)	446.7	511.8	108.5	112.7	2.9	2.9
$N_2M_1GA_0$	1.9	2.6	186.8	193.5	469.2	523.6	109.2	114.1	1.3	1.4
$N_2M_2GA_0$	2.0	2.2	183.8	184.7	257.7	263.6	**131.3**	**132.9**	(0.6)	(0.7)
$N_2M_0GA_1$	2.1	2.3	239.2	245.8	445.2	366.5	110.2	114.1	3.6	3.7
$N_2M_1GA_1$	1.9	1.8	223.8	223.7	303.0	420.0	111.8	112.7	2.1	2.1
$N_2M_2GA_1$	2.0	1.9	188.4	188.4	211.5	350.1	104.6	105.5	7.6	7.6
$N_2M_0GA_2$	2.1	2.2	204.3	203.3	451.4	502.6	126.2	126.6	3.9	3.8
$N_2M_1GA_2$	0.8	0.8	237.7	237.3	443.5	438.6	103.6	104.3	3.2	3.2
$N_2M_2GA_2$	2.1	2.6	236.1	211.6	457.5	447.7	115.5	104.4	3.6	3.6
$N_3M_0GA_0$	2.4	2.7	126.3	125.5	211.7	218.7	106.7	107.1	11.2	11.1
$N_3M_1GA_0$	**3.3**	3.1	171.5	178.3	273.0	247.4	113.7	111.3	7.8	7.8
$N_3M_2GA_0$	3.1	3.1	**299.4**	**300.1**	302.1	424.6	114.1	116.1	2.1	2.1
$N_3M_0GA_1$	3.0	3.2	165.1	167.3	**475.7**	485.0	95.6	93.2	8.8	8.7
$N_3M_1GA_1$	3.2	**3.3**	247.7	249.9	443.2	503.5	115.6	110.2	1.2	1.2
$N_3M_2GA_1$	2.6	2.6	191.5	192.6	448.1	(107.2)	105.6	107.0	3.9	3.9
$N_3M_0GA_2$	3.0	3.1	294.6	197.2	454.1	446.0	106.0	106.6	1.3	1.3
$N_3M_1GA_2$	2.6	2.7	145.3	145.6	406.2	**653.2**	110.6	109.3	6.9	6.7
$N_3M_2GA_2$	2.7	2.8	137.6	137.8	306.8	434.7	106.8	107.9	15.8	15.8
P-value	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
LSD 5%	0.3	0.3	1.0	12.4	2.6	36.9	2.2	8.3	0.1	0.2

S1= Season 1 (March 2019-July 2019); S2= Season 2 (October 2019-February 2020), Bolded values = Highest; Bracketed values = Lowest *Means followed by the same letter or no letter (but not shown) within a column are not significantly different according to the LSD Test at $P = 0.05$.

The present results showed that interaction effect was significant on N, P, K and beta-carotene (Table 4). A study by Mondal *et al.* (2020) found a significant interaction effect of nitrogen and mulch on peanut plants' N, P and K, while having highest accumulation of the same nutrients thereby supporting the results of this study. Interaction of mulch (seaweed extracts), organic N fertilizer and different N rates significantly increased N, P and K in leaves of summer squash (El-Afifi *et al.*, 2009). On the contrary, Siddiqui *et al.* (2008) found no significant interaction effect of N and GA_3 on N, K and Na in *Brassica juncea* leaves. Thus, the results depend on the species assessed.

CONCLUSION AND RECOMMENDATIONS

Nitrogen, potassium and magnesium levels in the multi-purpose pumpkins were significantly increased by the N fertilizer. Results also showed that nitrogen, phosphorus, potassium, magnesium and beta carotene contents were significantly affected by mulching and GA_3. N fertilizer, mulching and GA_3 significantly affected the N, P, K, Mg and beta carotene on the leaves of multi-purpose pumpkins. The interaction effect of nitrogen, mulch and GA_3 on N, P, K, Mg and beta-carotene in leaves was significant in all seasons. This shows that nitrogen, mulch and GA_3 are key factors in evaluation of the mineral and metabolite composition in leaves of multi-purpose pumpkins.

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