PRODUCTION OF MINERAL NUTRIENT-RICH MULTIPURPOSE PUMPKIN LEAFY VEGETABLES USING INTEGRATED NITROGEN, MULCH AND GA_3

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ABSTRACT

Understanding the effect of nitrogen, mulch and gibberellic acid on minerals and metabolites in multipurpose pumpkin (*Cucurbita moschata* Duch) is important since it is a dependable source of food, providing families producing it with various diets that contribute to household food and nutrition security. However, production of the pumpkin using optimal or integrated inputs has not yet been embraced in most African countries, resulting in under-realization of its maximum potential. To respond to this challenge, a split-split plot experiment arranged in randomized complete block design and replicated three times was conducted for two seasons from January 2019 to July 2020. The nitrogen (0, 50, 100 and 150 kg N/ha) was assigned to main plots, mulch (no mulch, black-painted and unpainted rice straws) to sub-plots, and gibberellic acid (GA_3) (0 mg/L, 40 mg/L and 80 mg/L) to split-plots. Nitrogen was applied as calcium ammonium nitrate (CAN) in two equal doses for each rate 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 to plants using a 1-L sprayer, starting with 40 mg/L, followed by 80 mg/L, once during the fourth week post-emergence. Data collection was done fortnightly from the fourth week after emergence up to fruit harvest stage. Data values were subjected to analysis of variance using SAS software version 9.3 and means separated using the least significant difference test at α=0.05. All the measured parameters were significantly (P<0.05) different. Highest levels of K and Mg were obtained for 100 kg N/ha. On the other hand, P and beta-carotene were highest where unpainted rice straws were used, while application of 80 mg/L GA_3 yielded high amounts of P and K. Results further showed that combined N fertilizer, mulch and GA_3 consistently had significant (P<0.05) effects on N, P, K, Mg and beta-carotene (highest 23 ppm was for $N_1M_1GA_1$). Therefore, sole nitrogen fertilizer, mulch, GA_3, and combined rates that promote the desired mineral nutrient and beta-carotene contents in multi-purpose pumpkin leaves should be adopted and applied, depending on the kind.

Keywords: Minerals, metabolites, multipurpose pumpkins, leaves, nitrogen, mulch, GA_3

INTRODUCTION

The *Cucurbitaceae* species, *Cucurbita moschata* (multipurpose pumpkin) acts as a dependable source of food, providing families producing it various diets. Multipurpose pumpkin leaves, fruits and seeds are immensely important to consumers. Nutritional value of pumpkins fruits is high, but varies depending on the species and cultivar. Pumpkin fruit flesh is tasty and valuable since it contains many biologically active materials and distinguished dietary qualities (Jukneviciene *et al.,* 2013). Pumpkins contain numerous mineral nutrients, vitamins A, B1, B2, B6, C, E, and β-carotene, among others. They are also rich in carbohydrates, particularly starch and sugars, whose amount depends on climatic conditions, species and cultivar. Pumpkins have low calorific value, which fluctuates from 15 to 39 kcal (Murkovic *et al.,* 2004).

Nitrogen is the most commonly required element during pumpkin production, although phosphorous is needed to promote seedling vigour, maximum production and high fruit quality (Mahfouz and sharaf-eldin, 2007). It is commonly applied in two side-dressings, the first at the 2-4 leaf stage and the second when vines start branching. Excessive N favours vegetative growth over reproductive growth and can inhibit fruit set. The nitrogen rate must be low enough by the time of flowering so that the plant will form fewer new leaves after fruits begin to grow to allow more sugars to go into fruits, rather than to 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). Mulching with grass resulted in over 55% of the available nitrogen getting released into the soil during the first 4 months of application for pumpkin production (Fang *et al.*, 2011).

Yamaguch and Kamiya (2000) reported that gibberellins play an essential role in many aspects of growth and development of pumpkins such as seed germination, stem elongation and flower development. Gibberellins delay senescence, improve growth and development of chloroplasts, thereby intensifying photosynthetic efficiency that culminates in increased yield (Yuan and Xu, 2001). The present study assessed the effect of combined nitrogen fertilizer, mulch and GA_3 on mineral nutrient content multi-purpose pumpkin leaves.

MATERIALS AND METHODS

The experiment was conducted on a farm that lies at 0^0 19' S, 37^0 38' E and 1535 m above sea level. The site receives average annual temperature of 19.5ºC (12.2ºC - 23.2ºC) and experiences two rainy seasons with March through June constituting the long rainy season and October through December constituting the short rainy season. The average annual rainfall is 1200 mm (http://en.climate-data.org). The soils are humic Nitisols, deep, strongly weathered, well drained with a clayey subsurface horizon and high cation exchange capacity (Jaetzold et al., 2006; Koskey *et al.*, 2017).

A three factor split-split block experiment embedded in 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 nitrogen, mulch and three GA_3. Nitrogen occupied main plots, mulch sub-plots and GA_3 split-plots. The nitrogen rates were 0, 50, 100 and 150 kg N/ha applied as CAN in two split equal doses for each rate, at three weeks post-emergence and at the beginning of flowering. The amount of CAN fertilizer used per experimental unit was derived as: a) 50 Kg N/ha = 76.9 g CAN/4 m^2, b) 100 Kg N/ha= 153.8 g CAN/4 m^2, c) 150 Kg N/ha = 230.7 g CAN/4 m^2.

The mulch type was none, black-painted and unpainted rice straws that were easily available near the experimental site in required quantities. The black-painted and unpainted dry rice straws were placed on the respective split plots after land preparation. Painting of the rice straws was done by dipping in a 200 L drum containing the black paint solution and then spreading on the ground to air-dry. The mulch was uniformly spread on the soil to achieve 20 cm thickness. Planting holes were marked and opened during seed sowing.

The GA_3 rates used were 0, 40 and 80 mg/L. The GA_3 granules were dissolved in 50 ml alcohol and then topped up to 1-L stock solution using distilled water. The required spray concentration was prepared from the stock solution by diluting with distilled water. A few drops of acceptable commercial sticker were added to solutions to facilitate the uptake of the GA_3 into leaves. The GA_3 solution was sprayed to the plants with a 1-L hand-held sprayer. Spray of lower rate was applied first followed by next higher rate. It was done once during the fourth week after emergence. To avoid drift, spraying was done on a calm morning.

Soil analysis was done at the KALRO National laboratories Kabete before plant establishment to establish the amount of additional fertiliser to apply. The soil was sampled using a zigzag sampling pattern across the experimental field. A soil auger and plastic containers were used. Two different composite samples were taken from 0-15 cm and 16-30 cm, respectively. The soil pH, total N, available P, K, Ca, Mg, organic carbon, and trace elements were measured (Chang and Laird, 2002).

Data values were collected for two seasons. Season 1 lasted from March 2019 to July, 2019 with 1,004 mm rainfall, and Season 2 lasted from October 2019 to February 2020 with 1,260 mm rainfall. 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. Mg was determined by Fourier transform Infrared Spectrophotometry, K 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 Mineral Nutrients and Beta-carotene in Leaves

Nitrogen fertiliser 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 in leaves.

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.

The effect of nitrogen fertiliser on the potassium content was significant (*P*<0.05) 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 in S1 and S2, respectively.

Nitrogen had a significant effect on magnesium in both seasons. The 100 kg N/ha nitrogen fertiliser 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 nitrogen fertiliser was applied magnesium content was lowest during both seasons.

There was a significant (*P*<0.05) effect of N on beta-carotene in both seasons. The 0 kg N/ha 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 fertilizer rate up to 100 kg N/ha in both seasons.

The effect on N, P, K and Mg contents showed a significant increase as nitrogen fertiliser increased up to 100 kg N/ha (Table 1). However, the highest nitrogen fertilizer rate of 150 kg N/ha slightly decreased N, P, K and Mg contents of pumpkins leaves probably due to dilution effect in the stimulated lush vegetative growth. 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 increased up to 80 kg N /ha. El-Shabrawy (1997) observed that nitrogen in squash leaves increased as nitrogen rate increased from 60 kg N/ha to 120 kg N/ha, but P and K percentages were not affected by increase in nitrogen rate. High ppm of these minerals in pumpkin leaves may be attributed to increased availability of nitrogen in the soil. Consequently, absorption would be higher and nutrient accumulation in leaves tissue would increase.

Effect of mulch on Mineral Nutrients and Beta-carotene in Leaves

Mulch had a significant (*P*<0.05) effect on nitrogen content in 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 straws. 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 2). 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 in S2. The no mulch produced the highest potassium content of 376.8 ppm and 392.1 ppm in S1 and S2, respectively (Table 2). The potassium content for unpainted rice straws was lowest of 292.6 ppm and 382.3 ppm in S1 and S2, respectively.

Mulch also had a significant (*P*<0.05) effect on magnesium in 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 when unpainted rice straw mulch was applied.

Mulch had a significant (*P*<0.05) effect on beta-carotene in both seasons. The unpainted rice straws produced the highest beta-carotene of 8.84 ppm and 6.75 ppm in S1 and S2, respectively. Beta-carotene of 6.03 ppm and 5.86 ppm in S1 and S2, respectively, was lowest for no mulch. Mulching affected P and beta-carotene contents in leaves positively.

The high P, K, Mg and beta-carotene contents were 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 maintain appropriate moisture and temperature levels for easy nutrient release into the soil 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.

Table 1: Effect of nitrogen on mineral nutrients 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 within a column are not significantly different according to the LSD Test at *P*= 0.05

T able 2: Effect of mulch on mineral nutrients 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
Black	1.81a	1.79b	202.85b	205.01ab	345.0b	392.1	108.95a	110.68a	6.80b	6.02b
Brown	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

S1= Season 1 (March 2019-July 2019), S2= Season 2 (October 2019-February 2020). *Means followed by the same letter within a column are not significantly different according to the LSD Test at *P*=0.05

Table 3: Effect of GA_3 on mineral nutrients 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 within a column are not significantly different according to the LSD Test at *P*=0.05

Effect of GA_3 on Mineral Nutrients and Beta-carotene in Leaves

Nitrogen content in leaf tissue was significantly (P<0.05) affected by GA_3 in 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 in 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 phosphorous content in both seasons. Application of 80 mg/L GA_3 yielded the highest phosphorous content of 210.04 ppm and 210.55 ppm in S1 and S2, respectively. The lowest phosphorous content of 192.22 ppm and 194.44 ppm in S1 and S2, respectively, was obtained under 0 mg/L GA_3.

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 0 mg/L GA_3, 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 in both seasons. The 0 mg/L GA_3 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 in 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 both seasons. The 40 mg/L GA_3 produced the highest beta-carotene of 9.93 ppm and 6.93 ppm in S1 and S2, respectively. Beta-carotene was lowest of 5.53 ppm and 5.50 ppm in S1 and S2, respectively, when 80 mg/L 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. The 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.

Effect of Nitrogen, Mulch and GA_3 Mineral Nutrients and Beta-carotene in Leaves

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

There was significant (P<0.05) effect of interaction on P in both seasons. The phosphorous content of 299.36 ppm was highest for $N_3M_2GA_0$, while the lowest phosphorous content of 85.33 ppm was recorded for $N_2M_0GA_0$ in S1 (Table 4). During S2, highest phosphorous content of 300.07 ppm was recorded for $N_3M_2GA_0$, while the lowest phosphorous content of 87.70 ppm was recorded for $N_2M_0GA_0$. The $N_3M_2GA_0$ (150 kg N/ha, unpainted rice straws and 0 mg/L GA_3) had the highest combined effect of nitrogen, mulch and GA_3 on phosphorous 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 interactive effect on potassium in S1 and S2, respectively. There was a significant (P<0.05) effect of interaction 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 interactive 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 $N_1M_1GA_1$ corresponding to 50 kg N/ha, black-painted rice straw mulch and 40 mg/L GA_3 had the highest interactive effect on beta-carotene in both seasons.

Table 4: Effect of nitrogen, mulch and GA_3 on minerals 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

The present results showed that interactive effect was consistently significant on N, P, K and beta-carotene contents (Table 4). A study by Mondal *et al.* (2020) found a significant interactive effect of nitrogen and mulch on N, P and K in peanut plants, thereby supporting the results of the present 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 interactive effect of N and GA_3 on N, K and Na in *Brassica juncea* leaves. Thus, the results depend on the species assessed.

CONCLUSION & RECOMMENDATION

Nitrogen fertilizer significantly increases nitrogen, potassium and magnesium contents in multi-purpose pumpkin leaves. Results also showed that nitrogen, phosphorus, potassium, magnesium and beta carotene contents are significantly affected by mulching, whereby mulching increases P and beta-carotene, but decreases N, K and Mg. Applied GA_3 significantly increases P and K, but significantly decreases N, P and beta-carotene. Combined nitrogen fertilizer, mulch and GA_3 significantly and consistently affect N, P, K, Mg and beta-carotene contents in multi-purpose pumpkin leaves. This shows that nitrogen fertiliser, mulch and GA_3 can be useful in evaluation of mineral and metabolite composition in multi-purpose pumpkin leaves. Therefore, sole nitrogen fertilizer, mulch, GA_3, and combined rates that promote the desired mineral nutrient and beta-carotene contents in multi-purpose pumpkin leaves should be adopted and applied, depending on the kind.

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