COMPLEMENTARY INFLUENCE OF NITROGEN, MULCH AND GIBBERELLIC ACID ON MULTI-PURPOSE PUMPKIN VEGETATIVE GROWTH

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Abstract: Plant productivity is often fixed early during vegetative growth. Multi-purpose pumpkin has valuable medicinal, nutritional and food security properties. However, cultivation using no inputs leads to poor vegetative growth that negatively impacts subsequent productivity. This study determined influence of nitrogen (0, 50, 100 and 150 kgN/ha), mulch as none, unpainted, and black-painted rice straws, and GA3(0, 40 and 80 mg/L) on its growth. Experimentation was done in randomized complete block design, replicated three times in two seasons, and each plant occupied 2mx2m space. Parameters measured were vine number, length, diameter, and leaf area. Analysis of variance used SAS and mean separation used the least significant difference test (α=0.05). N and GA3did not significantly ($P>0.05$) affect growth. Their effect showed a rise followed by a fall with increasing rate. Mulch significantly ($P<0.05$) enhanced growth. Combined N, mulch and GA3 complemented, leading to no significant variation in growth, except leaf area that ranged from 397cm2 to 708cm2($P=0.005$). Use of 100kgN/ha, black mulch, and 40mg/L GA3alone or combined is recommended to enhance growth.

Keywords: Leaf area, Photosynthate source, Vine number, Vine length, Vine diameter

1. INTRODUCTION

Pumpkin is an important and healthy food crop, rich in vitamins, minerals and antioxidants (Kiharason *et al.,* 2017). It is low in calorific content, making it a weight-loss-friendly food. Its nutrients and antioxidants are good in boosting the immune system, protecting eyesight, lowering risk of some cancers, and promoting heart and skin health (Ghanbari *et al*., 2007).Optimal pumpkin growth, development, production, and quality involve interaction of many inputs, and no single input alone can enhance them. According to Hewett (2006), temperature, relative humidity, water potential, light, cultural practices and pest management techniques are key pre-harvest factors that determine the inherent productivity of pumpkins.

Nitrogen is an essential plant nutrient. Although NH_4^+, NO_2^- and NO_3^- account for less than 5% of the total N in the soil, Liu *et al.* (2014) indicated that N is a critical element that most plants absorb. Nitrogen is the most important element for proper plant growth and development, which substantially increases and enhances yields and quality, as it plays critical roles in biochemical and physiological processes (Ullah *et al.,* 2010). Nitrogen enhances total leaf biomass which is a determinant of pumpkin leaf vegetable yield (Nasim *et al.,* 2012).

Mulch prevents fertilizer leaching since it slows down runoff, conserves soil moisture, increases soil temperature, suppresses weeds and prevents pathogen splash onto produce. It henceboostsplant health, physiology, shelf-life, yield and quality (Cerniauskiene *et al.,* 2015).

Gibberellic acid (GA_3) helps transport water and nutrients through the xylem and influences many biochemical and physiological processes like photosynthesis, respiration, protein synthesis, cell extension, wall thickness and stability (Abbas *et al.,* 2011), which are important in productivity and quality enhancement. It strengthens parthenocarpic flowers and fruits to prevent abortion, which is common in pumpkins particularly when pollination is inadequate (Mwaura *et al.,* 2014; Isutsa and Mwaura, 2017; Kiramana and Isutsa, 2019).

Improving vegetative growth of pumpkins through integrated input management practices will ensure productivity increment for producers, as well as food and nutrition security boost for the populace (Gomez *et al.,* 2020). Owing to the increasing demand of pumpkinsin Kenya, coupled with the challenge of ensuring that they are plentiful, receiving optimal inputs for enhancing vegetative growth isvery imperative. Sub-optimal pre-harvest inputs greatly contribute to poor returns through inadequategrowth (Nakazibwe *et al.,* 2019).

The key challenge in increasing production of pumpkin is finding optimal levels of integrated inputs to establish strong vegetative growth. Integrated input management impact has been given little attention by growers and researchers despite existence of enormous potential(Eyzaguirre*et al.*, 2006; Vorster *et al.,* 2008). Management of pumpkin performance has failed to start early in the farm. In most cases, pre-harvest factors and decisions are usually disregarded, under-estimated, or poorly rated, leading to low realization of pumpkin productivity potential(Otieno *et al.*, 2009; Berhanu and Moti, 2010). These factors and decisions include management procedures that lead to prevalence of poor soil fertility, pathogen-prone plant parts,few and small organs.

Whereas several studies have been done on factors strengthening*Cucurbita* species both in greenhouse and open field conditions,little research has been done, especially in Kenya to unravel the benefits of combined nitrogen, mulch and GA_3 on pumpkin vegetative growth that impacts reproductive parameters (Karanja *et al.*, 2014). The present research determined the influence of combined N, mulch and GA_3 on vegetative growth of multi-purpose pumpkin.

2. MATERIALS AND METHODS

2.1 Research Site Description

The reported study was conducted in Chuka University's Horticultural Research Farm between January 2019 and August 2020. The farm lies at0^o 19' S, 37^o 38' E and 1535 m above sea level. The average annual temperature is 19.5^oC (12.2ºC to 23.2ºC). It experiences two rainy seasons with the long rains occurring from March to June and short rains from October to December (Jaetzold *et al.,* 2006). The average annual rainfall is 1200 mm (http://en.climate-data.org). The soils are humic nitisols, deep, strongly weathered, well drained, with clayey subsurface horizon and high cation exchange capacity (Koskey *et al.,* 2017).

2.2 Experimental Design and Treatments

Threefactors (nitrogen, mulch and GA_3) were tested in a randomized complete block design with three replications. Each experimental plot measured 2m x 2m separated from others by 1 m space. Nitrogen was assigned to main-plots, mulch to sub-plots and gibberellic acid split-plots. The nitrogen rates 0, 50, 100 and 150 kg/hawere applied as CAN in two equal doses at three weeks post-emergence and at the beginning of flowering. The amount of CAN used per experimental unit was calculated 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.

Mulch assessed wasnone, unpainted and black-painted rice straws that were easily available nearthe experimental site. The black-painted and unpainted dry rice strawswere placed on their respective split plots after land preparation. Painting of the rice straw was done by dipping in a 200-L drum containing black paint solution and spreading out on the soil to air-dry. The rice straws were uniformly spread to achieve 20 cm thickness. Planting holes were marked and opened in rice straw mulch during pumpkin seed sowing.

Gibberellic acid 3 rates used were 0, 40 and 80 mg/L. The $GA_3$was dissolved in 50ml alcohol and topped up to 1 L stock using distilled water. Spray solution was prepared by diluting the stock solutionwith distilled water. A few drops of commercial sticker were added to the spray to facilitate uptake of GA_3 into leaves. The GA_3solution was sprayed using a 1-L sprayer. Lower rate was sprayed first followed by higher rate. Spraying was done once during the 4^{th} week after emergence. To avoid chemical drift, spraying was done on calm mornings.

2.3 Pumpkin Establishment and Management

The field was prepared to appropriate tilth required for pumpkin growth. Mulch was laid in line with treatments just before sowing seeds. All recommended phosphorus and potassium straight fertilizers were applied just before seed sowing. Two seeds were placed at the centre of each split plot and one was uprooted two weeks after emergence. All plots were kept weed-free through uprooting and manual weeding. Irrigation was done using drip tubes to supplement rain during drought. Pest control was done as necessary using recommended pesticides and rates. The vines were coiled as and when required while leaving them in contact with the soil. Data values wererecordedfor all experimental plants, except the guard row ones.

2.4 Data Collection and Analysis

Data was collected for Season 1 running from March 2019to July, 2019 with 1,004.3 mm rainfall, and Season 2 running from October 2019 to February 2020 with 1,259.6 mm rainfall. The total branches per plant were counted and recorded every 14 days from the 4th week up to the 12th week of plant growth.Vine length was measured fortnightly from the 6th up to the 12th week using a measuring tape. Vine diameter was measured fortnightly from the 6th week up to the 12th week at the 4th internode using a measuring tape.Data was recorded on one vine per plant. This was the first produced vine since it was perceived to have received all inputs.

Non-destructive assessment was done for leaf area. Three leaves per plant each from a different branch at the 6th node were used.Length (L) was measured along the central rib from the apex to the base, while the longest width (W) was obtained perpendicular to the central rib. Measuring was repeated fortnightly and three times starting the 6th week from emergence. Average leaf area in cm^{2}was calculated as: Leaf Area= $[(L_1*W_1) + (L_2*W_2) + (L_3*W_3)]/3$, Where: L_{1-3} = Length for the three readings.W_{1-3} = width for three readings(Silva *et al.*, 1998).Data values for number of branches, vine length, vine diameter and leaf area per plantwere subjected to analysis of variance, using the SAS software version 9.3. Mean separation was performed using the least significant difference test at $a = 0.05$.

3. RESULTS AND DISCUSSION

3.1 Effectof Nitrogen on Vegetative Growth

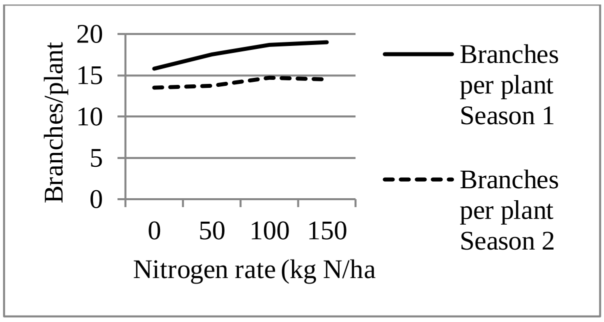
Nitrogen fertilizer had no significant effect (P>0.05) on the number of branches during both seasons (Figure 1). Application of 150kg N/ha produced the highest number of branches during S1, while 100kgN/ha produced the highest number in S2. In S1, the branches increased with increase in N fertilizer up to 150kg N/ha. The number of branches increased with increase in N fertilizer during S2 up to 100kg N/ha and then there was a slight reduction from 14.7 to 14.5. The control had the fewest number of branches during S1 and S2. The branches werefewer in S2 than in S1which could be due to seasonal effects.

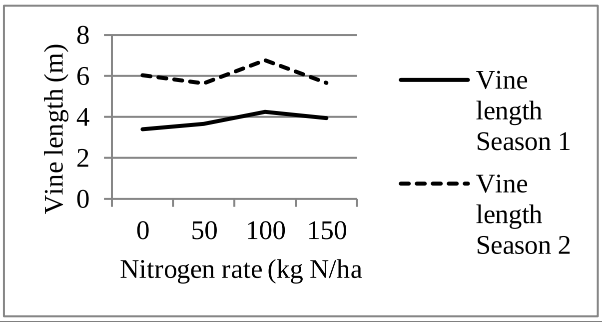
Nitrogendid not significantly(P>0.05) affect vine length in both seasons. The 100kg N/ha had the longest vines (Figure 1). Vine length increased with rise in N up to 100kg N/hain S1. The increase in vine length as a percentage ranged from 43.9% to 77.6% in S2 compared to S1. The vine length was 3.40 m and 6.04 m for0 kg N/ha in S1 and S2, respectively.

The effect of nitrogen fertilizer on vine diameter in S1 and S2 was not significant (P>0.05). The 100 kg N/ha produced thicker vine diameter of 4.11 cm and 4.26 cm in S1 and S2, respectively. Vine diameter increased with increase in N fertilizer up to 100 kg N/ha in both seasons. The control treatment had the thinnest vines of 3.94 cm in S1 and S2.

Nitrogen had no significant (P>0.05) effect on leaf area in S1 and S2. Application of 100 kg N/ha produced the highest leaf area of 579.6 cm^2 and 444.6 cm^{2}in S1 and S2, respectively. Leaf area was least when nitrogen was applied at 50 kg N/ha during both seasons.

Upon assimilation, the high 150 kg N/hapromoted better growthby increasing branches, which are essential in leaf production (Figure 1). Treatments that promote branch growth are highly valued in pumpkins. Similarly, Zhang *et al.* (1999) reported that plants receiving low nitrogen develop elevated root: shoot ratio with short branches, while higher levels of NO_3- inhibit root growth and lead to a decrease in the root: shoot ratio.





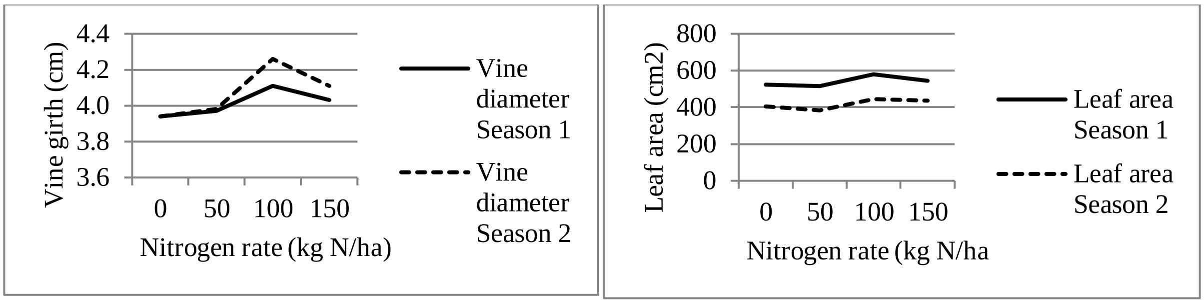


Figure 1: Effect of nitrogen on vegetative growth

Nitrogen did not have a significant effect on vine length and diameter, which nonetheless increased with increase in nitrogen up to 100kg N/ha and then decreased (Figure 1). Ngetich *et al.* (2013) reported that nitrogen stimulate vegetative growth. Research has shown that under nitrogen deficiency, plants will have stunted growth with small leaves, while application of excess nitrogen leads to lush plants with soft tissue and late maturity (Wolf, 1999). Josiah *et al.* (2007) attributed the increase in leaf area of cucumber to assimilation of nutrients particularly nitrogen from the soil. The significant response of leaf area to high nitrogen rates indicated that nitrogen was taken up by the plants and subsequently utilized in cell multiplication, amino acid synthesis and energy generation that act as structural components of chloroplasts (Ngetich *et al.*,2013).

3.2 Effectof Mulch on Vegetative Growth

Mulch had a significant ($P<0.05$) effect on branches in S1 only (Table 1). Branches were highest when black-painted rice straws were applied. The effect on vine length was significant ($P<0.05$) in S1,but not significant ($P>0.05$) in S2. Vine length was longest when black-painted rice straw mulch was applied in both seasons (Table 1). When black-painted rice straw mulch was applied, vine diameter was higher compared to when unpainted rice straw mulch or no mulch was applied in both seasons. The leaf area was significant in S1only, although black-painted mulch gave the highest leaf area of 588.3cm^2 and 425.1 cm^2 for S1 and S2, respectively.

Table 1: Effect of mulch on vegetative growth

Mulch type	Branches per plant		Vine length (cm)		Vine diameter(cm)		Leaf area (cm^2)	
	S1	S2	S1	S2	S1	S2	S1	S2
Control	15.8b	14.3	3.50b	6.02	4.01	4.06	511.3c	415.0
Black	19.1a	14.8	4.00a	6.28	4.05	4.10	588.3a	425.1
Brown	18.3a	13.2	3.92a	5.79	3.97	4.05	523.6b	410.6
P-value	*0.001**	*0.203*	*0.025**	*0.583*	*0.868*	*0.939*	*0.008**	*0.85*
LSD 5%	0.84	17.96	0.371	0.98	0.322	0.318	48.45	54.78

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 $a = 0.05$

The results obtained in the present study were attributed to the fact that black mulch has the ability of maintaining high soil water content and temperature compared to no mulch. These results agreed with those of Aniekwe and Anike (2015) on mulched cucumber that produced higher number of vines, number of leaves, leaf area and vine length. Similar observations were also reported by Singh and Kamal (2012) in tomato and Mahadeen (2014) in okra and squash. Li *et al.* (2001) reported that black mulch improves water use efficiency through better utilization of soil water, thus increasing the size of vines. Black mulch also reduces soil water evaporation and deep soil water exploitation to support shoot biomass accumulation and dry matter optimization (Zhao, 1995). Similarly, Ajibola and Amujoyegbe (2019) indicated that black mulch is linked to decomposition of organic residues in the soil which in turn add more nutrients.

3.3 Effect of GA_3on Vegetative Growth

There was no significant (*P*>0.05) effect of GA_3on branches in S1 and S2 (Figure 2). The 18.1 and 14.5 branches in S1 and S2, respectively, were the highest when 40 mg/L $GA_3$was applied. The number of branches was lowest when 80 mg/L GA_3 was applied. The effect of GA_3 on vine length was not significant (*P*>0.05) during S1 and S2. The vine length was longest 4.05 m when 40 mg/L GA_3 was applied in S1 and 6.47 m when no GA_3 was applied in S2.

When 80 mg/L GA_3 was applied to pumpkin plants, vine diameter was highest in S1. When no GA_3 was applied to pumpkin plants in S2, vine diameter was 4.15 cm (Figure 2). The effect of GA_3 on vine diameter was not significant (*P*>0.05) during S1 and S2. Results also showed that leaf area of 547.3 cm^2 during S1 was the highest when 80 mg/L GA_3 was applied and 433.9 cm^2 when 40 mg/L GA_3 was applied during S2. However, the effect of GA_3 on leaf area was not significant (*P*>0.05) during both seasons (Figure 2).

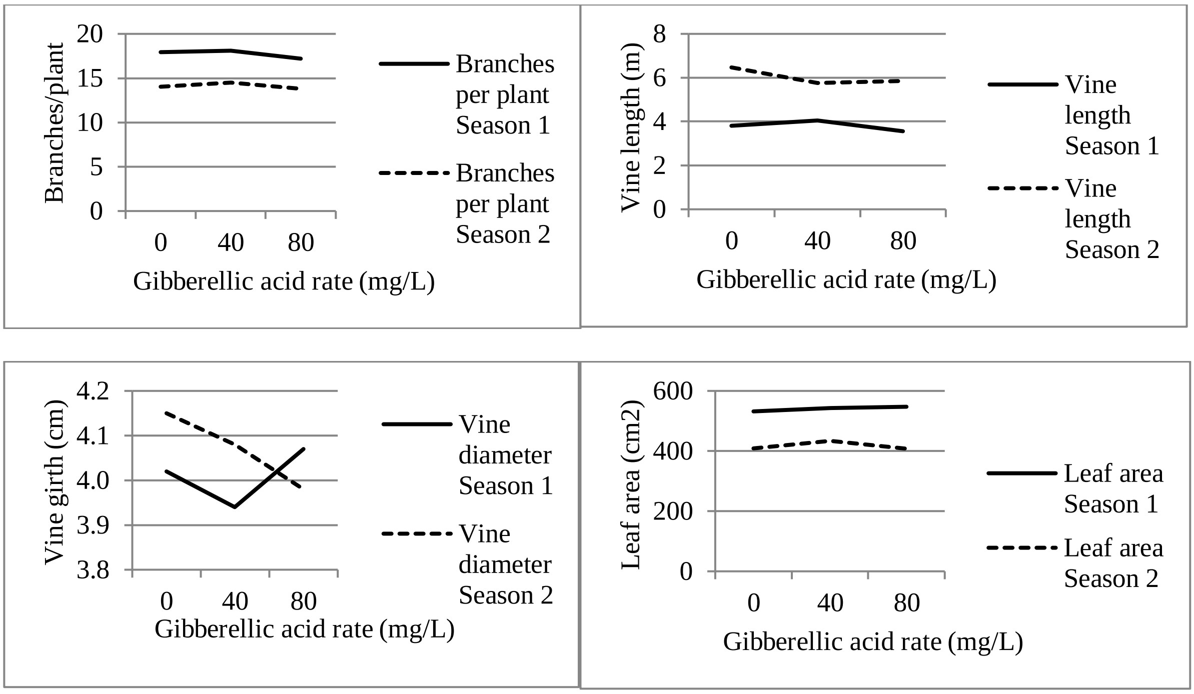


Figure 2: Effect of GA_3on vegetative growth

Vines and leaf area are important morphological parameters that contribute to plant yields (Darasteanu *et al.,* 2005). Gibberellic acid has been found to play an essential role in stem elongation and flower development (Yamaguchi and Kamiya, 2000). The present study shows that GA_3 did not have a significant effect on the number of branches, vine length, vine diameter and leaf area. Such results are expected since gibberellins promote reproductive growth.

Gibberellic acid has also been found to affect the length and diameter of cucurbits positively. Jadav *et al.* (2010) suggested that GA_3enhances cucumber growth either by boosting epicotyl length and height through raising plasticity of cell walls after hydrolysis of starch into sugars that lower water potential of cells, leading to entrance of water into cells, thereby causing elongation. These osmotically driven responses cause rise in photosynthetic activity, accelerate translocation and efficiency of utilizing photosynthetic products that lead to rapid cell division and improved cell elongation in growing portions (Jadav *et al.,* 2010).

The trend for GA_3showed that highest leaf area was obtained when 80 mg/L and 40 mg/LGA_3were applied in S1 and S2, respectively. This result agreed with that of Ajay *et al.* (2018), who reported that plant growth regulators profoundly influence assimilatory surface area and associated characters in cucumbers. This is attributable to stimulatory impact of plant growth regulators on cell division and enlargement, which in turn boostleaf area (Geeta *et al.,* 2010).

3.4 Effect of Nitrogen, Mulch and GA_3on Vegetative Growth

Thehighest23 brancheswere for $N_3M_1GA_1$in S1, while the lowest 14 werefor $N_0M_0GA_0$. In S2, the highest 19 brancheswere for $N_3M_0GA_1$, while the lowest11 branches were for $N_0M_2GA_1$ (Table 2). The $N_3M_1GA_1$ (150kg N/ha, black-painted rice straw mulch and 40 mg/LGA_3) and $N_3M_0GA_1$ (150kg N/ha, no mulch and 40 mg/LGA_3) had the highest branchesin S1 and S2, respectively. No significant effect (P>0.05) was observed due to interactiveeffect of nitrogen, mulch and GA_3 on the number of pumpkin vines in S1 and S2.

Vine length was longest 5.20 m for $N_3M_1GA_1$, while the shortest 2.55 m was for $N_1M_0GA_2$ in S1. In S2, the longest vines, measuring 6.77 m were for $N_3M_0GA_0$, while the shortest 4.41 m were for $N_3M_2GA_1$ (Table 2). The $N_3M_1GA_1$ (150 kg N/ha, black-painted rice straw mulch and 40 mg/L GA_3) and $N_3M_0GA_0$ (150 kg N/ha, no mulch and 0 mg/L GA_3) had the highest combined effect on vine length in S1 and S2, respectively. No significant effect (P>0.05) resulted due to interactive effect of nitrogen fertiliser, mulch and GA_3 on pumpkin vine length during both seasons.

The greatest diameter of 4.77 cm developed under $N_2M_1GA_1$, while the least diameter of 3.46 cm resulted under $N_1M_2GA_0$ in S1. The 4.60 cm was the greatest diameter for $N_2M_1GA_2$, while $N_0M_1GA_1$had the least diameter of 3.38 m in S2. Results showed that $N_2M_1GA_1$ (100 kg N/ha, black-painted rice straws and 40 mg/L GA_3) and $N_2M_1GA_2$(100kg N/ha, black-painted rice straws and 80 mg/L GA_3) yielded the greatest diameter in S1 and S2, respectively. No significant (P>0.05) interactive effect of nitrogen fertiliser, mulch and GA_3 on pumpkin vine diameter was observed in both seasons (Table 2).

The $N_1M_1GA_1$ yielded the highest 703.8 cm^2 leaf area, while $N_3M_0GA_0$ had the lowest 397.1 cm^2 leaf area in S1 (Table 2). The 519.7 cm^2 was the highest leaf area for $N_2M_0GA_1$, while $N_0M_2GA_1$had lowest leaf area of 339 cm^2 in S2. The $N_1M_1GA_1$ (50 kg N/ha, black-painted rice straw mulch and 40 mg/L GA_3) and $N_2M_0GA_1$ (100 kg N/ha, no mulch and 40 mg/L GA_3) had the highest combined effect of nitrogen fertiliser, mulch and GA_3 on leaf area in S1 and S2, respectively. The combined factor effect of nitrogen, mulch and GA_3 on leaf area was significant in S1 only.

In the present study, the interactive effect of the applied nitrogen fertiliser, rice straw mulch and GA_3 plant growth regulator on the number of branches, vine length, vine diameter and leaf area of multipurpose pumpkin was not significant during both seasons, except for leaf area during season 1 where it was significantly low under low inputs and significantly high as the nitrogen fertiliser, rice straw mulch and GA_3input ratesapplied were increased.

The significant first season results of multipurpose pumpkin leaf area corroborate those of Ibraheem*et al.* (2019), who reported a significant interactive effect of nitrogenous fertiliser and black plastic mulch on leaf area of summer squash. Similarly, Ullah *et al.* (2017) observed that the thickest fibres in diameter of ramie plants were obtained when low NPK + GA_3 were applied and the effect was significant.

Table 2: Effect ofnitrogen, mulch and GA_3 on vegetative growth

Treatment	Number of branches per plant		Vine length (m)		Vine diameter (cm)		Leaf area (cm^2)	
	S1	S2	S1	S2	S1	S2	S1	S2
$N_0M_0GA_0$	(14)	15	3.7	6.3	4.5	4.4	552.4a	420.1
$N_0M_1GA_0$	18	15	3.6	6.5	4.0	4.4	582.5a	425.8
$N_0M_2GA_0$	16	13	3.9	6.4	3.8	3.8	443.5b	373.2
$N_0M_0GA_1$	14	17	3.4	6.5	3.9	4.1	470.0b	513.8
$N_0M_1GA_1$	18	15	3.6	5.6	3.9	(3.4)	610.7a	430.7
$N_0M_2GA_1$	15	(11)	2.9	4.6	3.9	4.3	499.7b	(339.0)
$N_0M_0GA_2$	15	14	3.1	6.5	3.9	3.8	502.8b	394.0
$N_0M_1GA_2$	15	12	2.9	6.2	3.7	3.8	522.9b	370.9
$N_0M_2GA_2$	16	12	3.4	5.3	3.9	3.5	534.1b	373.1
$N_1M_0GA_0$	16	14	4.1	5.4	4.2	3.9	544.9a	366.8
$N_1M_1GA_0$	17	12	3.7	5.8	3.6	3.9	426.0b	309.6
$N_1M_2GA_0$	19	14	3.9	4.8	(3.5)	3.7	555.2a	381.9

$N_1M_0GA_1$	17	13	3.5	5.8	3.8	4.4	416.3b	406.4
$N_1M_1GA_1$	18	16	4.0	6.3	4.0	4.1	**707.8a**	415.1
$N_1M_2GA_1$	19	13	4.0	6.2	3.8	3.8	490.1b	404.5
$N_1M_0GA_2$	15	12	(2.6)	4.8	4.1	3.9	461.2b	368.7
$N_1M_1GA_2$	17	15	2.9	5.1	4.2	3.9	495.9b	403.9
$N_1M_2GA_2$	20	14	4.2	6.6	4.6	4.1	540.4b	393.5
$N_2M_0GA_0$	15	14	4.1	5.9	4.1	4.2	603.6a	422.4
$N_2M_1GA_0$	19	15	4.4	5.8	4.0	4.6	598.7a	437.1
$N_2M_2GA_0$	20	16	3.8	6.7	4.2	4.4	567.1a	510.2
$N_2M_0GA_1$	16	17	4.4	5.2	4.0	4.4	525.6b	**519.7**
$N_2M_1GA_1$	22	14	4.9	6.2	**4.8**	4.1	630.7a	420.3
$N_2M_2GA_1$	19	14	5.1	6.5	4.1	3.9	578.5a	428.8
$N_2M_0GA_2$	17	18	3.8	6.3	3.9	4.1	616.7a	446.3
$N_2M_1GA_2$	21	12	4.7	5.4	3.9	**4.6**	582.0a	388.7
$N_2M_2GA_2$	18	13	4.2	6.3	4.0	4.2	513.2b	428.1
$N_3M_0GA_0$	18	13	3.3	**6.8**	3.8	4.0	(397.1b)	380.0
$N_3M_1GA_0$	20	14	4.3	4.8	4.5	4.0	608.1a	445.9
$N_3M_2GA_0$	21	14	3.8	5.5	4.1	4.6	503.2b	436.1
$N_3M_0GA_1$	17	**19**	3.8	6.1	3.8	4.1	525.6b	402.3
$N_3M_1GA_1$	**23**	15	**5.2**	5.6	3.6	4.0	590.3a	466.6
$N_3M_2GA_1$	20	15	4.0	(4.4)	3.7	4.5	481.8b	459.2
$N_3M_0GA_2$	16	16	3.4	6.7	4.2	4.1	519.0b	459.9
$N_3M_1GA_2$	20	16	3.7	4.9	4.5	4.0	703.5a	466.5
$N_3M_2GA_2$	16	13	3.8	6.1	4.1	3.9	576.2a	399.6
P-value	*0.876*	*0.499*	*0.90*	*0.623*	*0.718*	*0.524*	***0.005***	*0.730*
LSD 5%	5.311	52.59	1.75	4.025	1.099	0.884	164.84	152.09

S1= Season 1 (March 2019-July 2019); S2= Season 2 (October 2019-February 2020). Bolded values = Highest; Bracketed values = Lowest.

4. CONCLUSIONS AND RECOMMENDATIONS

Nitrogen fertilizer does not significantly affect the number of branches, vine length, vine diameter, and leaf area of multipurpose pumpkin leaves consistently. Mulch has no significant effect on vine diameter only. The effect of mulch is positive and significant on number of branches, vine length, leaf area, depending on season. The effect of GA_3 on the number of branches, vine length and vine diameter is consistently not significant. Combined nitrogen, mulch and GA_3 significantly affect only leaf area, but not branching, vine length and diameter of multipurpose pumpkin.

Therefore, the present study recommends application of 100 kg N/ha and mulching with black-painted rice straws to enhance branching, vine length, vine diameter and leaf area growth. It also recommends application of 40 mg/L GA_3 to boost vegetative growth in terms of increasing branches, vine length, vine diameter and leaf area. Since vegetative growth in season 2 was different from that in season 1, trials should be conducted in respective regions to ascertain the best season for vegetative growth of pumpkin vegetables and fruits.

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