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ENHANCEMENT OF MULTI-PURPOSE PUMPKIN (*Cucurbita moschata* Duchesne) YIELDS USING NITROGEN, MULCH AND GIBBERELLIC ACID

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ABSTRACT
Pumpkin (*Cucurbita moschata* Duchesne) acts as a dependable source of food, providing families producing it with various diets and contribution to household food security. Unravelling effects of nitrogen, mulch and gibberellic acid (GA_3) on seed, fruit weight and number of multipurpose pumpkin would help maximize economic and medicinal value of pumpkin. Subsequently, an experiment arranged in split-plots in randomized complete block design and replicated three times was conducted at Chuka University in two seasons from January 2019 and July 2020. The main plots were assigned to nitrogen (0, 50, 100 and 150 kg N/ha CAN), split plots to mulch (no mulch, black- painted and unpainted rice straws), while sub-plots to GA_3 (0, 40 and 80 mg/L). Each nitrogen rate was applied in equal doses at three weeks seedling 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 using a knapsack sprayer, starting with 40 mg/L followed by 80 mg/L. Data collection was done fortnightly from the fourth week after emergence and data values subjected to analysis of variance using the SAS software and means separated using least significant difference at *P*=0.05. Nitrogen effect was significant on the number of seeds in both seasons. The 150kg N/ha CAN during the first and the second season had the highest number of fruits (3.70≈9250 and 5.63≈14,075 fruits/ha), total fruit weight (11.28≈28,200 kg/ha and 17.61≈44,025 kg/ha) and number of seeds (603.9≈1,509,750 and 575.7≈1,439,250 seeds/ha) respectively. Black painted mulch produced significantly higher total weight and number of fruits during the first season compared to the unpainted and no mulch. It also gave better results in all the treatments. Effect of GA_3 was insignificant during both seasons. The results show that 150kg N/ha and black- painted mulch would give yields of economic value to farmers. Use of GA_3 may not result in increased number of seeds, total weight and number of pumpkin fruits.

Keywords: AIVs, Fruit weight, Fruit set, Plant growth regulators, Pumpkin seeds

INTRODUCTION

Pumpkin (*Cucurbita moschata* Duchesne) 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 (Jukneviciene 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 calorific value fluctuates from 15 to 39 kcal (Murkovic et al., 2004).

The nutritional value of pumpkin seeds is based on high protein content (25-51%) and high percentage of oil that ranging from 40-60%, up to 60.8% (Abdel-Rahman, 2006). The oil contains the fatty acids, 25-35.9% oleic and 40.4-55.6% linoleic acid, stearic and palmitic acids typically ranging from 5.2-7.5% and 6.2-12.4%, respectively (Applequist et al., 2006). The grains of pumpkin contain medicinal raw materials that are used for production of pharmaceutical products like peponen and pepostrin used in overcoming prostatic hypertrophy and urinary tract irritation (Sedghi et al., 2008). The seeds have shown good results in the therapy of minor disorders of the prostate gland and the urinary bladder (Pericin et al., 2008). Nitrogen 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). Nitrogen is commonly applied in two side-dressings, the first at the 2-4 leaf stage and the second when vines start to develop runners. The goal is to grow plants with a large canopy of leaves, maintaining healthy leaves as long as possible. This can be done by maintaining adequate levels of fertilizer taking care not to over-fertilize the crop with nitrogen (Efthimiadou et al., 2010). Excessive N favors vegetative over reproductive growth and can inhibit fruit set. The nitrogen level must be low enough by the time of flowering so that the plant will form fewer new leaves after fruit begin to grow to allow more sugars to go to the fruit, rather than to developing leaves and vines (Min-gang, 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., 2007). Mulching is one of the ways used to better domesticate soil and to increase crop yield. It has been found to reduce the evaporation of moisture, regulate soil temperature, improve soil structure and increase organic matter stocks and improves plant nutrition (Wyenandt et al., 2008; Splawski, 2012). Fang et al. (2007) 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. According to Yamaguch and Kamiya (2000), gibberellin (GA) hormone plays an essential role in many aspects of plant growth and development of pumpkins such as seed germination, stem elongation and flower development. Gibberellic acid (GA3) is an important PGR that affects plant growth and development by inducing metabolic activities and regulating nitrogen utilization (Sure et al., 2012). It also plays a significant role in seed germination, endosperm mobilization, stem elongation, leaf expansion, reducing the maturation time and increasing flower and fruit set and their composition (Roy & Nasiruddin, 2011). 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 number of fruits, total fruit weight and the number of seeds of multi-purpose pumpkins.

MATERIALS AND METHODS

Site and Experiment

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 has a 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 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 are 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, 40 and 80 ppm. Gibberellic acid was dissolved in 50 ml alcohol and 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 commercial sticker were added to facilitate uptake. The gibberellic acid solution was sprayed to the plants with a knapsack sprayer. 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 chemical drift, spraying was done during a calm morning following wind direction. Soil analysis was done before plant establishment. It was done at the KALRO National Laboratories Kabete. It was done to establish the nutrient contents which informed the effects of nitrogen applied in the experiment. The soil was sampled using a zigzag sampling design across the experimental field. A soil auger and plastic containers were used. Two different composite samples were prepared, 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 assessed (Chang & Laird, 2002).

Data Collection and Analysis

Data was collected for two seasons (long and short rain seasons). Fruits with dry fruit stalk and hard skin were harvested from each experimental unit, counted and weight measured. Three fruits randomly selected per treatment were used to take data on the number of seeds. Seeds were counted and the number per treatment recorded. 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

Effects of Nitrogen Fertilizer on Number of Fruits, Total Fruit Weight and Number of Seeds

Nitrogen fertilizer had no significant effect ($P>0.05$) on the number of fruits during both seasons (Table 1). Application of 150kg N/ha produced the highest number of fruits with 3.70 and 5.63 respectively during S1 and S2 respectively. In both seasons, the number of fruits increased with increase in N fertilizer up to 150kg N/ha. There was a 24.7% to 36.7% increase in the number of fruits during S2 compared to S1. The control treatment had the lowest number of fruits with 3.07 and 4.11 during S1 and S2 respectively. Nitrogen fertilizer had significant effect on the total weight during S1 ($P<0.05$) but insignificant during S2 ($P>0.05$). Application of 150 kg N/ha produced the highest total weight in both seasons; (11.28 ≈28,200 kg/ha and 17.61≈44,025 kg/ha respectively (Table 1). Total weight increased with increase in N fertilizer up to 150 kg N/ha during both seasons. The increase in the total weight ranged from 53.1% to 58.1% in S2 compared to S1. At the control treatment, the total weight was 5.12 kg and 12.21 kg. N fertilizer had significant effect ($P<0.05$) on the number of seeds during S1 and S2. Application of 150 kg N/ha produced the highest number of seeds of 603.9 during S1. The number of seeds increased with increase in N fertilizer up to 150 kg N/ha during S1.

Table 1: Effects of nitrogen fertilizer on number of fruits, total weight and number of seeds

Nitrogen rate (kg/ha)	Number of fruits		Total fruit weight (kg)		Number of seeds	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**
Control	3.07	4.11	5.12	12.21	464.8	480.3
50	3.37	4.48	6.30	13.42	540.4	466.8
100	3.40	5.37	7.56	16.81	579.2	571.3
150	3.70	5.63	11.28	17.61	603.9	575.7
P-value	0.908	0.408	0.013*	0.296	0.009*	0.004*
LSD 5%	2.118	2.237	3.744	7.243	66.1	54.25

Effects of Mulch on Number of Fruits, Total Weight and Number of Seeds

Mulch had significant effect on the number of fruits and total weight during S1 ($P<0.05$) but the effect was insignificant during S2 ($P>0.05$). Results further showed that the effect of mulch was insignificant on the number of seeds during both seasons ($P>0.05$). Highest number of fruits was produced when black-painted rice straws mulch was applied during both seasons at 4.53 and 5.17 for S1 and S2 respectively. According to the results, when black- painted rice straws mulch was applied, total fruit weight was higher compared to when unpainted rice straws mulch or no mulch was applied. The same was the case in seeds that were 570 and 547.4 in S1 and S2 respectively.

Table 2: Effects of mulch on number of fruits, total weight and number of seeds

Mulch type	Number of fruits		Total fruit weight (kg)		Number of seeds	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**
Control	2.36	4.58	5.43	13.41	536	502.5
BL	4.53	5.17	8.81	16.37	570	547.4
BR	3.25	4.94	8.44	15.27	534	520.7
P-value	0.004*	0.601	0.044*	0.25	0.313	0.621
LSD 5%	1.161	1.217	2.837	3.635	54.5	47.12

Effects of Gibberellic Acid on Number of Fruits, Total Weight and Number of Seeds

Gibberellic acid had no significant effect on the number of fruits, total fruit weight and the number of seeds during both seasons ($P>0.05$). Application of 80 ppm produced highest number of fruits of 3.56 during S1. However, control treatment had 5.58 fruits during S2 which was higher compared to when 40 ppm and 80 ppm were applied. In S1, the number of fruits increased with increase in GA_3 up to 80 ppm. Results also showed that application of 80 ppm of GA_3 resulted to 7.61 kg total weight which was highest compared to when 40 ppm was applied and the control treatment. In S2, total weight was highest in the control treatment. The number of seeds was also high in the control treatment and when 80 ppm of GA_3 was applied during S1 and S2 respectively.

Table 3: Effects of gibberellic acid on number of fruits, total weight and number of seeds

GA3 (mg/L)	Number of fruits		Total fruit weight (kg)		Number of seeds	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**
Control	3.14	5.58	7.54	16.53	561	518.4
40	3.44	4.53	7.53	13.68	524	516.2
80	3.56	4.58	7.61	14.83	556	536.0
P-value	0.804	0.082	0.997	0.252	0.313	0.498
LSD 5%	1.310	1.040	2.356	3.428	52.1	36.62

DISCUSSION

Results in this study showed that the number of fruits, total weight of the fruits and the number of seeds were enhanced by N fertilizer across the sampling periods. This increase might be due to the fact that plants during flowering and fruit setting stages need a high amount of N and other nutrients to perform the biological activities. The dependence of fruit weight on fertility and season in Cucurbits had earlier been reported by (Oloyede & Adebooye, 2005). The optimum N fertilizer rate in this study was 150 kg/ha where the number of fruits, total weight of the fruits and the number of seeds were higher than all other N rates and the effect was insignificant on the number of fruits. The results differ from those of Martinetti & Paganini (2006) who found out that the number of fruits and fruit total weight of pumpkin decreased in Lithuania due to increased fertilizer rates.

Ramakrishna et al. (2006) denoted that evaporation from the soil accounts for 25-50% of the total quantity of water used. In this study, using black-painted rice straws mulch produced positive effect on number of fruits, total fruit weight and the number of seeds as compared to unpainted rice straws mulch or no mulch. The results agree with those of Mahadeen (2014) who found out that fruit number and weight of okra and squash increased using back plastic mulch. Number of fruits and total fruit weight are products of vegetative growth improvement which might be explained in view that mulches improve moisture conservation and availability, which ultimately leads to improve plant growth as reported by Ban et al. (2009) and Mamkagh (2009). Earlier researchers indicated that improvement in yield parameters resulting from increased vegetative growth as a result of using mulches might be due to the enhancement in photosynthesis and other metabolic activities (Bhatt et al., 2011; Parmar et al., 2013). Results further showed that application of GA_3 from 40 ppm to 80 ppm resulted to increase in the number of fruits, total fruit weight and the number of seeds. GA_3 has been found to promote growth and elongation of cells which would explain the increase in the yield parameters evaluated. The present findings are in agreement with the results of Kazemi (2014) and Majumdar (2013), which revealed an increase in fruit weight and number of fruits per plant of tomato and cabbage using different combinations of GA_3.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study exhibited the significant effect of N fertilizer and mulching on the total weight and number of seeds. The use of GA_3 produced insignificant effect. Application of 150kg N/ha produced the best results on all the yield parameters evaluated and therefore the study recommends the use of 150kg N/ha by the famers for them to have high yields of multi-purpose pumpkins. Further, it is recommended to use black painted rice straws mulch as soil mulching to enhance yield of multi-purpose pumpkins. Gibberellic acid had no significant effect on the number of fruits, total fruit weight and the number of seeds. However, use of 80 ppm produced higher yields compared to 40 ppm. In some instances, the control treatment produced better results compared to when GA_3 was applied and therefore the study recommends caution by farmers if GA_3 is to be used.

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