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Full Length Research Paper

Effects of NPK fertilizer and season on the flowering and sex expression of pumpkin (*Cucurbita pepo* Linn.)

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Effects of NPK 15:15:15 compound fertilizer and planting season on flowering and sex expression of pumpkin were analyzed at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria in year 2010. Results deciphered that day to 50% flowering, number of male and female flowers responded to season than fertilizer rates. Late season planting reached 50% flowering 5 days earlier than that of early season. At zero fertilizer rate 50% flowering was attained at 56 days after planting while the application of 250 kg ha^{-1} NPK (15:15:15) delayed 50% flowering by 4 days; at 100 – 150 kg NPK ha^{-1}, the delay was 2 days. Early season had more number of male and female flowers per plant (25) than the late season ones (15). The ratio of male to female flowers was 3:1. Higher number of flowers per plant was obtained at 100 kg NPK ha^{-1} (25) than in control (12). However, increasing fertilizer rate above 100 kg does not significantly (P<0.05) improve the number of flowers produced.

Key words: Fertilizer rates, flowering, season, sex expression, pumpkin.

INTRODUCTION

Most cucurbits are monoecious, that is, they have separate male and female flowers on the same plant. Monoecious cultivars may differ in degree of female sex expression, some having a higher proportion of female to male flowers or male to female flowers. Generally, they produce many more staminate than pistillate flowers and go through a progression of floral development (Robinson and Decker-Walters, 1997). Nitsch et al. (1952) determined that young squash plants are initially vegetative with underdeveloped male flowers, later they bear normal female as well as male flowers. If squash plants are not pollinated, ultimately they may produce enlarged female flowers and parthenocarpic fruits.

Sex expression in the Cucurbitaceae is controlled by environmental as well as genetic factors. Unfavourable growing conditions such as lack of water can cause a slowdown in flower production. In general, female sex expression is promoted by low temperature, low nitrogen supply, short photoperiod and high moisture availability, which are conditions that encourage the buildup of carbohydrates. These environmental factors influence the levels of endogenous hormones (especially ethylene, auxin and gibberellic acid, chemical composition), which in turn influence sex expression (Robinson and Decker-Walters, 1997; Achakzai, Kayani, 2002; Achakzai, 2012). Monitoring the production of flowers in Cucurbits is important. The number of female flowers per plant determines the number of fruits. In most monoecious cucurbit plants, the ratio of staminate to pistillate flowers greatly varies when the plants are grown under different environmental conditions, including photoperiod, temperature, nutrient availability, or treated with auxins and plant hormones (Lau and Stephenson, 1993; Swiader et al., 1994; Yin and Quinn, 1995). Consequently, any means of regulating environmental factors influencing the ratio of staminate to pistillate

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Table 1. Pre-planting and post-planting soil chemical and physical properties at 0-15 cm depth in the experimental site.

Chemical Property	**Pre-planting**	**Post-planting**
pH (H_2O) (1:2)	6.4	6.8
Organic Carbon (g kg^{-1})	9.8	7.8
Total N (g kg^{-1})	1.7	0.85
Available P (mg kg^{-1})	5.80	6.50
Exchangeable cations (cmol/kg)		
K^+	0.4	0.32
Ca^{2+}	0.38	0.45
Mg^{2+}	2.81	2.85
Physical Property		
Sand (g kg^{-1})	802	790
Silt (g kg^{-1})	97	99
Clay (g kg^{-1})	101	111

flowers is valuable, since yields of high grade fruits depend, within limits, upon this ratio. This study evaluated the influence of increased nutrient fertilizer and planting season on the flowering traits and sex expression in pumpkin.

MATERIALS AND METHODS

The studies were conducted at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria, during the early season (May to August) and late season (August to November) of year 2010. The site is located on latitude 07º 28'N and longitude 04º 33'E and about 244 m above sea level. Ile-Ife lies in the rainforest vegetation characterized by bimodal rainfall pattern with peaks in June and September. Early rains usually last from late March/early April to the end of July. There is always the 'August break' whereby there is little or no rainfall. Late rain usually starts in late August and ends in early November at Ile-Ife. The experiment was laid down in a randomized complete block design (RCBD) with six replicates. NPK fertilizer @ 15:15:15were applied at 0, 50, 100, 150, 200, 250 kg ha^{-1}. There were 6 plots per replication; each plot size was 10 m x 12 m and consisted of 7 rows. Alley between plots was 3 m, while the plants were spaced 2 x 2 m. Random samples of the studied soil were taken before starting and after the research from every plot at a depth of approximately (30cm) to study the necessary analysis of physical and chemical characteristics of the soil. The results of the analysis are shown in (Table1).

Land was ploughed twice and harrowed once before sowing. Two seeds per hole were sown and the seedlings were thinned to one plant per stand at 2 weeks after planting (WAP). The NPK fertilizer was added in two equal halves at 2 WAP and 6 WAP (weeks after sowing). Insecticide (lambda-cyhalothrin) was applied fortnightly from 6 to 10 weeks after planting. Post-emergence herbicide, glyphosate was applied at the rate of 200ml/15litre at 4 and 7 WAP for weed control.

Days to first flower after planting were taken by visually observing the plants in each plot. Days to 50% flowering after planting were taken by visual rating when 50% of the plants had flowered. Number of male and female flowers was recorded by sampling 5 plants per plot.

All data were subjected to combined analysis of variance SAS (2003). Means squares, where significantly different, were separated by using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Regression analysis was performed for traits that had significant season and fertilizer mean squares.

RESULTS

Climatological data regime

Rainfall pattern at Ile-Ife, Osun-state, during the early season of the experiment from May to August, 2010 ranged from 7 to 16 mm. Maximum temperature ranged from 28 to 32^{0}C while minimum temperature ranged from 21.0 to 23.0^{0}C. The average rainfall, average maximum temperature and average minimum temperature during the period were 13.2 mm, 29.9^{0}C and 22.5^{0}C respectively. During the late season of the experiment, August to November 2010, rainfall pattern ranged from 9-16 mm. Maximum temperature ranged from 28 to 31^{0}c while minimum temperature ranged from 22.0 to 22.4^{0}c. The average rainfall, average maximum temperature and average minimum temperature during the period were 15.4 mm, 30.1^{0}C and 22.2^{0}C respectively. (Table 2)

Soil properties of the experimental site

The results of general chemical and physical properties

Table 2. Summary of weather data at Ile-Ife, Osun-State during the Cropping year (2010)

Months	Total Rainfall (mm)	Average temperature (Min) ^{0}C	Average temperature (Max) ^{0}C	Solar Radiation (MJ/m^2/day)
January	0	22.1	33.9	11.12
February	3.7	23.8	35.6	13.38
March	3.9	24.1	34.7	13.61
April	6.7	23.9	33.9	14.71
May	14.4	23.0	31.7	12.74
June	6.9	23.0	30.6	12.45
July	16	21.9	28.6	11.16
August	15.5	22.2	28.4	10.13
September	15.2	22.1	29.7	13.40
October	22	22.0	30.6	13.66
November	8.7	22.4	31.4	9.30
December	0	21.5	32.8	7.83

Table 3: Combined analysis of variance showing means squares for flowering traits of Pumpkin

Source	DF	Days to 1st flower (d)	Days to 50% flower (d)	No of male flowers (n)	No of female flowers (n)
Season	1	18**	29.39**	396.68**	88.88**
Rep within season	10	0.27	0.61	2.12	0.22
Fertilizer	5	19.46**	18.26**	157.78**	26.77**
Season*Fertilizer	5	0.13	0.69	1.31	2.59**
Pooled error	50	0.31	0.35	2.17	0.44
CV (%)		1.18	1.03	9.7	11.8

* = Significant at 0.05 level of probability, and ** = significant at 0.01 level of probability.

of the soil in the experimental area before and after cropping are presented in Table 1. The surface soil was slightly acidic with a pH of 6.4. The soil of the site was low in organic carbon (9.8 g kg^{-1}) and also moderate in total nitrogen (1.7 g kg^{-1}). Available P (Bray-P) was 5.80 mg kg^{-1} and was considered inadequate when compared with the critical value of 10-16 mg kg^{-1} for southwest Nigeria, (Sobulo *et al.,* 1975; Agbede and Aduayi, 1978). Exchangeable Mg^{2+} was 0.38 cmol/kg. This was considered adequate in Southwest Nigeria where the critical value is 0.2-0.4 cmol/kg. The values of exchangeable Ca^{2+} and K^{+} were 2.81 and 0.40 cmol/kg, respectively and were considered adequate considering the critical values of 2.5 and 0.16-0.25 cmol/kg, respectively for Ca^{2+} and K^{+}. The soil of the site was classified as sandy loam. There was a reduction in the amount of N and organic carbon left in the soil after cropping.

Season and fertilizer effects on the flowering traits and sex expression of pumpkin

Season and fertilizer significantly influenced the number of male & female flowers, days to first flowering and 50% flowering. However, significant interaction between season and fertilizer was only observed in number of female flowers $plant^{-1}$ (Table 3). Season influence showed that the first flowering in pumpkin appeared four days earlier in the late season than in the early season (Table 4). Table 5 showed that days to first flowering were delayed with increased fertilizer rates. Days to first flowering at control and 50 kg ha^{-1} was between 45 to 46 days after planting and this was delayed by 1 to 2 days and 3 to 4 days as fertilizer rates increased from 100-150 and 200 and 250 kg ha^{-1} NPK respectively. Season influence showed that day to 50% flowering was 5 days earlier in the late season (Table 4). Fertilizer influence caused delay in days to 50% flowering from 2 to 4 days when the rate increased from 150 kg to 250 kg ha^{-1}. Days to 50% flowering were earliest (56 days) without fertilizer and at the lowest rate of fertilizer application (Table 5).

Season influence showed that the number of male flowers from early season and late season were significantly different. Number of male flowers in the early season was 28% more than the number of male flowers in the late season and fertilizer rates increased the number by 70 and 100% (Tables 4 and 5). Season

Table 4. Flowering traits of Pumpkin as affected by season

Season	Days to 1st flowering	Days to 50% flowering	Number of male flowers	Number of female flowers
Early season	49	60	18	7
Late season	45	55	13	5
LSD (0.05)	1.2	3.2	3.4	1.2

NS = not significant at 5% level of probability.

Table 5: Flowering traits of pumpkin as affected by NPK fertilizer

NPK level (kg ha^{-1})	Days to 1st flowering	Days to 50% flowering	Number of male flowers plant^{-1}	Number of female flowers plant^{-1}
Control	45d	56c	9c	3c
50	46c	56c	13b	4b
100	47b	58b	18a	7a
150	47b	58b	17a	7a
200	49a	60a	18a	7a
250	49a	60a	18a	7a

Means with the same letter in each column are not significantly different at 5% level of Probability using Duncan's multiple range test.

influence showed that there are more female flowers during the early season than in the late season. An average of seven flowers/plant was observed in the early season unlike five flowers/plant in the late season (Table 4). The number of female flowers increased with fertilizer rates, the effects were marked from the application at 100 to 250 kg ha^{-1}. At these high rates, female flowers increased by 100% when compared with the non-fertilized control plots (Table 5).

The season x fertilizer interaction effect on number of female flowers showed that more female flowers were produced in the early season. The response of number of female flowers fitted into quadratic equation with R^2 ranging from 0.91-0.93 (Figure 1). In late season optimal number of female flowers was obtained at 100-250 kg ha^{-1} NPK fertilizer but in early season it was 150- 250 kg ha^{-1} NPK. At control, the number is lower than at any fertilizer levels in both seasons.

DISCUSSION

NPK has been reported to depress flowering and encourage male flowers rather than female flowers (Kraup et al., 2002). In this study, number of flowers increased with fertilizer rates and the number of fruits are determined by the female flowers set plant^{-1}. Female flowers were three times lower than the male flowers across the different fertilizer rates. The modification of sex ratio in favour of female flowers using different factors such as mineral nutrients, most especially high levels of nitrogen has been most clearly demonstrated in monoecious cucurbits (Lau *et al*., 1995). Mineral nutrients influences sex expression in Squash. In soils that are deficient in K, the inclusion of k in the compound fertilizer increased the female flowers and subsequently enhanced fruit yield in squash (Abduljabbar and Ghurbat, 2010). In addition, Abd El-Fattah and Sorial (2000) reported that bio-fertilizer treatments significantly enhanced the induction of female flowers and reduced male flowers in Squash plant.

The mean square contribution to the number of female flowers as observed was higher for season than fertilizer and season by fertilizer interaction. It seems influence of rainfall had effect on flowering, for example in cowpea, more flowers and hence pods are produced in drier savanna areas than in rain forests. In this study, early season's crops (May to August) which happened to receive lesser rainfall and higher temperature (combination of minimum and maximum) than the late season's crops (August to November) produced greater number of flowers. Excessive rainfall could have accounted for lower number of flowers in the late season. In addition, higher sunlight duration between May and June might stimulate more flowers than in shorter day length in August and September.

Modification of sex expression in favour of pistillate flower have been reported to have potential to increase number of fruits per plant, higher yield of leaves and seeds in fluted pumpkin (Odejimi and Akpan, 2006).

Growth regulators have tremendous effects on sex expression and flowering in various cucurbits leading to

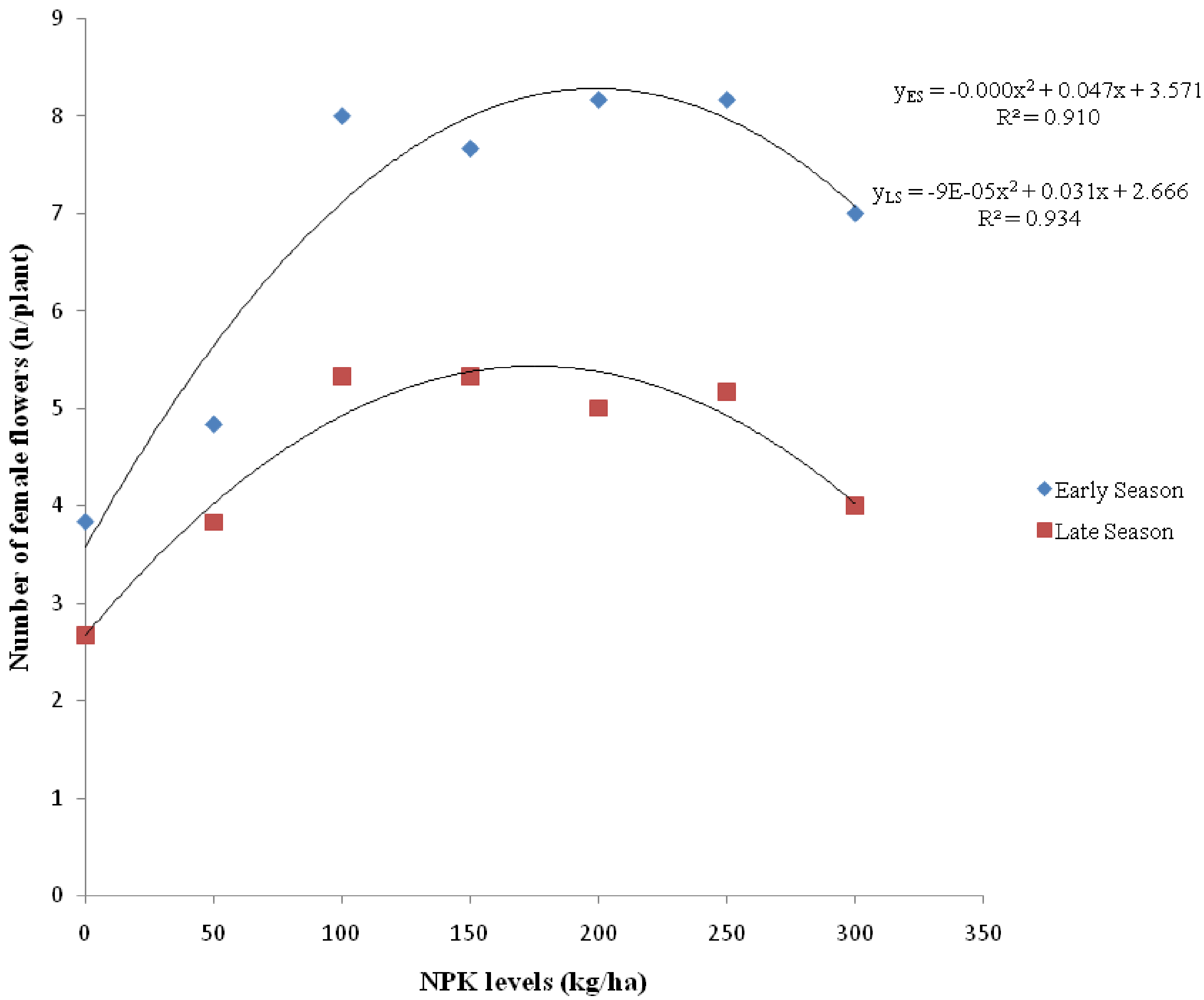

Figure 1. Number of female flowers of pumpkin biomass as affected by Season x NPK fertilizer

either suppression of male flowers or an increase in the number of female flowers (Al-Masoum, Al-Masri, 1999) without imposing any deleterious effect on the environment and human health. Exogenous application of plant growth regulators can alter the sex ratio and sequence if applied at the two- or four-leaf stage, which is the critical stage at which the suppression or promotion of either sex is possible in cucumber (Hossain et al., 2006).

The effects of hormones in sex expression appear to be relatively clear and direct while the effect of mineral nutrients seems to be indirect. Mineral nutrients might alter sex expression in plants through effects on hormonal balance (Salisbury and Ross, 1969). To increase fruiting in pumpkin, the improvement in the number of female flowers is suggested. This could be achieved with the introduction of exogenous hormones in addition to N fertilizer already in use in Cucurbits fruit production in Nigeria.

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