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Effects of Planting Dates on Nutritional and Phytochemical Compositions of Onion Varieties under Rain-Fed and Irrigation Facilities in Ogbomoso, Nigeria

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Abstract

Onion is a high value vegetable consumed in Nigeria on a daily basis, and it forms an integral part of diet but the nutritional quality is low due to lack of appropriate cultural practices. The study examined the effects of planting dates on the nutritional quality of onion varieties in Ogbomoso, Nigeria. Five onion varieties (Local white, local red, karibou, gandiol+ and safari) were subjected intofour different planting dates namely, two under rainfed (early April and August) and two under irrigation (early September and November). The 5 x 4 factorial treatment combinations were arranged in a Randomized Complete Block Design (RCBD) with three replicates. Onion bulbs and leaves were collected separately from six plants in each treatment and used for proximate analysis. The mineral (N, P, K, Ca and Mg), nutritional and phytochemical compositions (protein, fat, crude fiber, ash, moisture content, vitamin C and quercetin) of onion bulbs and leaves were assessed. Data collected were subjected to analysis of variance. The results showed that variety significantly influenced the minerals, nutritional and phytochemical compositions of onion leaves and bulbs. Karibou contained highest minerals, nutritional (except fat) and phytochemical compositions of onion leaves, while local white gave the least values. The vitamin C and quercetin contents of the onion bulbs were higher (20.08 and 0.59 g/mg, respectively) in karibou as compared to other varieties. Planting date exerted significant influence on the nutritional quality of onion leaves and bulbs. The highest quercetin content of 0.58 and 0.23 g/mg for onion bulb and leaves respectively, were obtained from onion planted in November, while April planting date gave the least values.

Keywords: Onion Bulb, Onion Leaves, Proximate Analysis, Nutritional Quality, Quercetin Content

Introduction

Onion (*Allium cepa* L.) is an important vegetable crop valued for its pungent or mild flavour and for being the essential ingredient of the cuisine of many regions **[1]**. It is one of the most important vegetables in the world, whose utility in Nigeria is ranked second to tomatoes based on the level of consumption **[2]**. It is one of the most commonly consumed vegetable crops in Nigeria and around the world. Onion is grown for its green leaves and bulbs, which are used in every home, almost daily. It is rarely used as sole dish or in large quantities, its main use lies in flavoring and seasoning of a wide variety of dishes. Its popularity is due to its aromatic, volatile oil, the allyl-propyl disulphide which imports a cherished flavour to food **[3]**.

Onion varieties are classified into two categories: long-day which is better for cool climate and short-day that is better for warm climates. They have various colours ranging from white to yellow to red with a flavour range from mildly sweet to more pungent onion **[3,4]**. Most onion cultivars are about 89% water, 9% carbohydrates (including 4% sugar and 2% dietary fibre), 1% protein, and

negligible fat. Onions contain low amounts of essential nutrients and have energy value of 166KJ (40 calories) in a 100g amount. Onions contribute savoury flavour to dishes without contributing significant caloric content **[5]**.

Onion is a rich source of nutrients, including vitamin B, C and G, protein, fiber, starch and a series of essential elements. The chemicals contained in onions are reported to be effective agents against fungal and bacterial growth; they protect against stomach, colon and skin cancers; they have anti-inflammatory, antiallergenic and antidiabetic actions; and they treat causes of cardiovascular disorders, including hypertension, hyperglycemia and hyperlipidemia while also inhibiting platelet aggregation **[6]**.

Onions bulbs are among the richest sources of dietary flavonoids and contributed to a large extent to the overall intake of flavonoids. Two types of flavonoids are important in alliums, the anthocyanins responsible for the colour in red- skinned onion cultivars and the flavonoids, which give a yellowish due to onion flesh and are important precursors for yellow and brown skin pigments. Flavonols are the predominant pigments of onions. At least 25 different flavonols have been characterized, and quercetin derivatives are the most important ones in all onion cultivars. Also, onion cultivars are index according to their flavonoids content measured as quercetin. Only compounds belonging to flavonoids; the anthocyaninsand the dihydroflavonoids have been reported to occur in onion bulbs. Yellow onions contain 270-1187mg of flavonols per kilogram of fresh weight (FW), whereas red onions contain 415-1917mg of flavonols per kilogram of FW. Quercetin 4'-glucoside and quercetin 3.4'-diglucoside are in most cases reported as the main flavonols in recent literature **[3]**.

Each variety has a different optimal planting date, which will influence onion performance. Onion is grown widely during the wet and dry seasons. However, there is need for more information on the nutritional quality of onion produced during the two seasons, particularly in the South west Nigeria.

Materials and Methods

Experimental Site

The field and laboratory experiments were conducted between 2018 and 2019 cropping seasons at the Teaching and Research Farm and in the Department of Crop Production and Soil Science respectively, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Ogbomoso is on latitude $8^{0}10^{1}$N and longitude $4^{0}10^{1}$E in the guinea savanna zone of southwest Nigeria.

Treatments and Field layout

The treatments involved five onion varieties (Local white, local red, karibou, gandiol+ and safari) and four different planting dates namely, two under rainfed (early April and August) and two under irrigation facilities (early September and November) with their various combinations. The 5 x 4 factorial treatment combinations were arranged in a Randomized Complete Block Design (RCBD) with three replicates. The experimental site was ploughed and harrowed and 60 raised beds were made. These were divided into three replicates with each replicate containing 20 beds. The size of each bed was 2 m x 2 m ($4m^2$) with the spacing of 0.5 m within and 1m between replicates. The total area of the experimental plot was 50.5m x 10m ($505m^2$).

Cultural Practices

The nurseries for onion were established two months before each planting date. The onion seeds were sown on nursery beds containing top soil and seedlings were raised for eight weeks before transplanting to the field. Uniform and healthy seedlings were transplanted into the field in order to ensure uniformity at 8 weeks after sowing at the spacing of 30 cm x 30 cm, giving a plant population of 111,111 stands per hectare. Supplementary water supply or irrigation was carried out after transplanting and continued during the dry period of the experiment. A recommended combined application of 65kg N/ha, 40kg P/ha and 45kg K/ha **[7]** was applied by band method, at 3 weeks after transplanting. Mulching was done immediately after sowing with the use of dried Guinea and Southern Gambia grasses which were carefully placed on each bed to help retain soil moisture, reduces weed problems among the plants and improves the soil fertility. Weeding was carried out as it became necessary by manual method using hoe. Insect pests were controlled with cypermethrin insecticides at 10 ml per 10 litres of water, sprayed at two weeks interval with the use of Knapsack sprayer.

Data Collection and Proximate Analysis

Six plants were randomly selected within the net plot, in each plot and tagged. Data were collected at 4 months after transplanting (MAT). Onion bulbs and leaves were collected separately from six plants in each treatment, dried and analyzed in the laboratory to determine the mineral contents (N, P, K, Ca and Mg), nutritional and phytochemical compositions (protein fat, crude fibre, ash, moisture content, vitamin C and quercetin) of onion as affected by treatments. Samples were analyzed according to the official method

of analysis described by the Association of Official Chemist **[8]**. Total N was determined using macro Kjeldahl **[9]**, the P and K contents of the plants were determined by wet digestion in nitric, sulphuric and perchloric acids. P was determined by vanadomolybdate date yellow colometry method. Digested samples were diluted and used to determine the concentration of K using atomic absorption spectrophometer **[8]**.

Statistical analysis

Data collected were analyzed using Standard Analysis System **[10]** for analysis of variance (ANOVA). Difference among treatments means was computed using Duncan Multiple Range test at 0.05 significant levels.

Results

Mineral Contents of Onion Bulbs

The mineral composition of onion bulbs showed that variety had significant (P≤0.05) effect on the P, K, Ca and Mg contents of onion bulbs **(Table 1)**. Karibou had the highest (5.28 g/mg) nitrogen content which is statistically similar to the values obtained for gandiol+ (5.15 kg/mg) and safari (4.99 g/mg) while local white gave the least (4.68 g/mg) value. Karibou had the highest P, K, Ca and Mg content of 35.08,161.49,161.40 and 10.11g/mg respectively, followed by Gandiol+ while local white recorded the least values. The phosphorus and potassium contents of the bulb of onion planted in November (34.39 and 161.97 g/mg, respectively) were significantly higher ($p \leq 0.05$) than the others, but no statistical difference was observed in the values obtained between December and August planting dates. Also, the planting date had significant ($p \leq 0.05$) effect on the calcium and magnesium contents of onion bulbs. The highest N, Ca and Mg contents of 5.55, 158.79 and 9.61 g/mg respectively were obtained from bulb of onion planted in November followed by December while April planting date gave the least values. Significant (P≤0.05) interaction was recorded between variety and planting date on the mineral compositions of onion bulbs.

Table 1: Effects of Variety and planting date on mineral composition of onion bulbs.

1.1. Mineral Contents of Onion Leaves

The mineral composition of onion leaves is presented in **Table 2**. The nitrogen, phosphorus, calcium and magnesium contents followed the same trend and significantly (P≤0.05) higher for karibou (0.23, 21.72, 130.97, 14.10 and 7.11 g/mg, respectively) as compared with other onion varieties. Planting date exhibited significant (P≤0.05) influence on the mineral compositions of onion leaves. The leaves of onion planted in November recorded the highest N, P, K, Ca and Mg contents (0.23, 21.7, 131.9, 14.25 and 7.33 g/mg, respectively) than in December, August and April planting dates. The interaction between variety and planting date exerted significant influence on the P, K, Ca and mg contents of onion leaves.

	N	P	K	Ca	Mg
Variety	……mg/100 g……				
Local White	4.68c	31.05e	147.79d	140.86e	7.97e
Local Red	4.82bc	31.83d	154.77c	187.37a	8.93d
Karibou	5.28a	35.08a	161.49a	161.10b	10.11a
Gandoil^{+}	5.15a	34.69b	157.14b	151.71c	9.63b
Safari	4.99b	33.56c	157.05b	150.07d	9.12c
Planting date					
April	4.35c	31.22c	148.36c	138.83d	8.49d
August	4.94b	33.60b	155.21b	149.06c	9.04c
September	5.44a	34.39a	161.97a	158.79a	9.61a
November	5.20ab	33.76b	157.04b	154.21b	9.46b
Interaction	ns	**	**	**	**

Along the same column, the means with the same letter are not statistically different at p< 0.05; ** = significant; ns= not significant

Table 2: Effects of Variety and planting date on mineral composition of onion leaves.

Nutritional and Phytochemical Compositions of Onion Bulbs

The onion bulb nutritional and phytochemical compositions revealed significant (P≤0.05) differences in the crude fibre and fat contents of the onion bulb among the varieties **(Table 3)**. Although, the highest crude fiber and fat contents (1.52 and 0.31 g/mg, respectively) were recorded for karibou, but no statistical difference was observed between the values obtained for Karibou and Safari. The ash and moisture contents of karibou were significantly (P≤0.05) higher (1.75 and 86.81 g/mg, respectively) than the other varieties. Planting date exerted significantly (p≤0.05) effect on the nutritional qualities of onion bulbs. Onion planted in November had the highest crude fibre, fat and ash contents (1.60, 0.31 and 1.77g/mg, respectively) followed by those planted in December while April planting date recorded the least values. Moisture content of onion bulb was significantly influenced by the planting date. The highest moisture content was recorded at April (87.14 g/mg) while December planting date gave the least (83.28 g/mg) value.

	Crude fiber	Fat	Ash	Moisture content	Vitamin C
Variety	……..mg/100 g…….…….…….…….				
Local White	1.55a	0.26b	1.77a	84.01e	9.58a
Local Red	1.47b	0.27ab	1.63b	85.21d	10.67a
Karibou	1.52a	0.31a	1.75a	86.81a	20.08a
Gandoil^{+}	1.45b	0.28ab	1.60b	86.15b	11.38a
Safari	1.50ab	0.29ab	1.51c	85.95c	11.19a
Planting date					
April	1.42c	0.24c	1.55d	87.14a	9.16a
August	1.49bc	0.27b	1.61c	86.51b	17.54a
September	1.60a	0.31a	1.77a	83.28d	12.25a
November	1.50b	0.29ab	1.67b	85.58c	11.37a
Interaction	ns	ns	**	**	ns
Along the same column, the means with the same letter are not statistically different at p< 0.05; ** = significant; ns= not significant					

Table 3: Effects of Variety and planting date on proximate and phytochemical compositions of onion Bulbs.

Although, there were no significant differences in the vitamin C content of onion bulb among the varieties, the highest value of 20.08 g/mg was obtained for karibou while local white gave the least (9.58 g/mg) value. The bulbs of onion planted in August recorded the highest (17.54 g/mg) vitamin C content while April planting date gave the least (9.16 g/mg) value. Karibou gave significant highest quercetin content (0.59 g/mg) which is statistically similar to that of Gandiol+ (0.54 g/mg) while local white recorded the least (0.39 g/mg) value **(Figure 1)**.

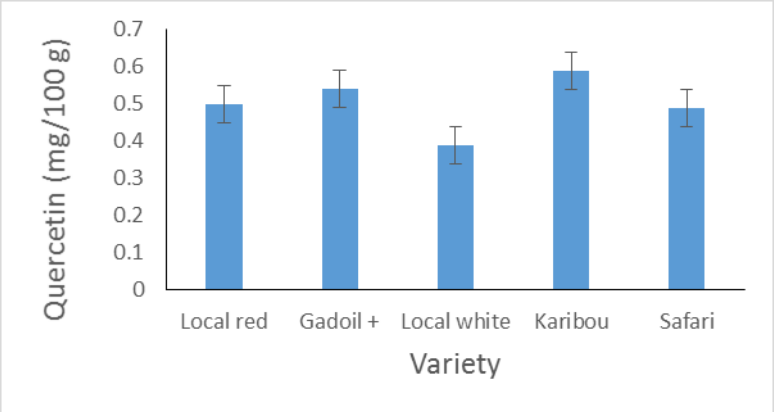

Figure 1: Effect of variety on quercetin content of onion bulbs.

Quercetin content (0.58 g/mg) obtained from bulbs of onion planted in November was significantly higher (p≤0.05) than those recorded in December, August and April planting dates **(Figure 2)**. The variety and planting date interaction effect had significant influence on the Ash and moisture contents of onion bulbs.

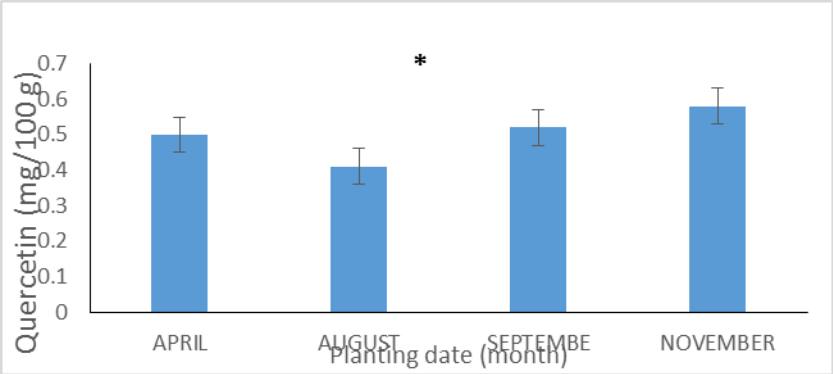

Figure 2: Effect of planting date on quercetin content of onion bulbs.

Nutritional and Phytochemical Compositions of Onion Leaves

The nutritional and phytochemical compositions of onion leaves revealed that karibou had significantly higher crude fibre content that are statistically similar to that of local red and white onion, while no statistical difference in the crude fibre content was observed between Gandiol+ and Safari **(Table 4)**.

	Crude fiber	Fat	Ash	Moisture content	Vitamin C
Variety	……..mg/100 g…….……..……..……				
Local White	1.51a	0.69c	0.61a	19.19d	7.18e
Local Red	1.59a	0.56bc	0.56bc	19.51c	9.27b
Karibou	1.61a	0.59ab	0.59ab	20.37a	9.43a
Gadoilt	1.52b	0.55cd	0.55cd	20.07b	7.92c
Safari	1.55b	0.52d	0.52d	20.19b	7.58d
Planting date					
April	1.46d	0.55d	0.50c	20.13a	7.21d
August	1.52c	0.66c	0.56b	19.86b	7.98c
September	1.61b	0.89a	0.63a	19.71c	9.68a
November	1.69a	0.83b	0.58b	19.78bc	8.22b
Interaction	*	*	ns	Ns	*
Along the same column, the means with the same letter are not statistically different at p< 0.05; ** = significant; ns= not significant					

Table 4: Effects of Variety and planting date on proximate and phytochemical compositions of onion leaves.

The crude fiber content was significantly influenced by the planting date, with leaves of onion planted in December recorded the highest (1.69 g/mg) while the least (1.46 g/mg) was obtained for April planting date. Variety exhibited significant effects on the fat, ash, moisture, Vitamin C and Quercetin contents in the onion leaves. The highest Fat, Moisture and Vitamin C content (0.80, 20.37 and 9.43 g/mg) were obtained from karibou while local white gave the least values. Local white variety had higher Ash content than the others. The highest quercetin content of 0.22 g/mg was obtained from local red closely followed by Karibou (0.20 g/mg), while local white gave the least value **(Figure 3)**.

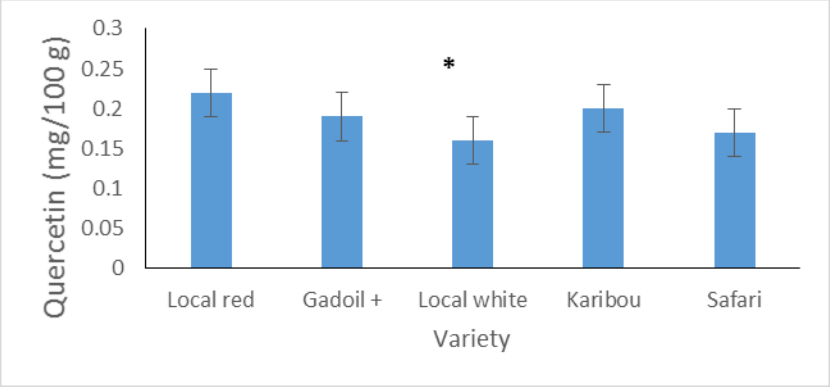

Figure 3: Effect of variety on the quercetin content of onion leaves.

The nutritional and phytochemical compositions of onion leaves were significantly affected by the planting date. The leaves of onion planted in December gave the highest crude fiber followed by November (1.61 g/mg), while the least (1.46 g/mg) value recorded at April planting date. The November planting date recorded the highest Fat, Ash, Vitamin C and quercetin **(Figure 4)** contents (0.89, 0.63, 9.68 and 0.23 g/mg) while local white gave the least value. The moisture content was higher (20.13 g/mg) in the onion leaves at April planting date as compared to the other planting dates.

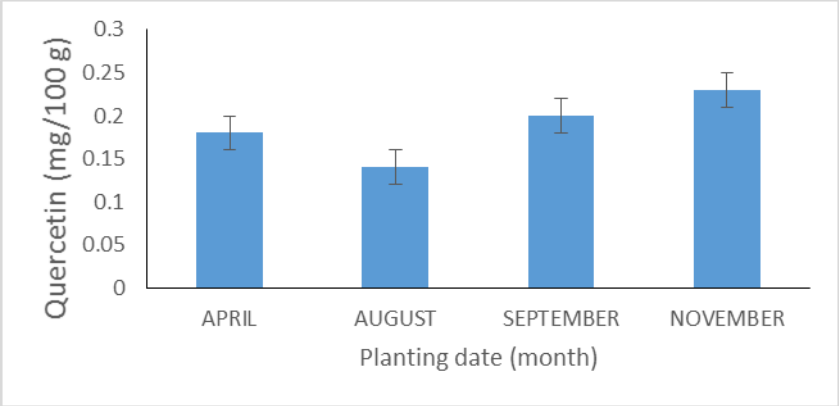

Figure 4: Effect of planting date on the quercetin content of onion leaves.

The combined effect of variety and planting date had significant influence on the crude fibre, fat and Vitamin C contents of onion leaves.

Discussion

The presence of nutrient elements in both the leaves and bulbs showed that onion is a rich source of nutrients. This corroborates the findings of Brewster (2016) **[3]**, who reported that onions are brimming with vitamin C, B1, B6, G, potassium, phosphorous, fibre, protein and starch. The nutritional compositions obtained in this study are very close to those reported by USDA (2017) **[5]**, that recorded about 89% water, 2% dietary fiber and negligible (0.1) fats. The low mineral nutrient contents obtained in this study are similar to those obtained by Atanda (2015) **[11]** who reported low amount of essential nutrients in onions.

The considerable differences that exist between onion varieties in nutritional and phytochemical contents, particularly quercetin agrees with the earlier work of Slimestad *et al.*(2007) **[12]**, they reported differences in the polyphenols content of onion varieties. Also, the variations in the nutritional and phytochemical contents among the onion varieties confirmed the findings of Ansari (2007) and Young *et al*. (2004) **[13,14]**, who reported that red onion is the most mild, sweet onion, contains a higher amount of antioxidants compounds and higher flavonoids than white and yellow onion. They submitted that quercetin which is a polyphenol compound is one of the beneficial compounds in red onion. Moreover, the higher quercetin, vitamin C and nutrient contents recorded for karibouwhich is red onion than other (white and yellow) varieties reconfirmed the work of Olsson (2010) **[15]** that reported the presence of quercetin in sweet and red onion cultivars at harvest. However, Local white and safari which are white onions contained more fiber than red onion, which corroborated the submission of Ansari (2007) **[13]**.

Brewster (1994) **[16]** reported wide range of diversity or variation in quality attributes and skin colour among onion cultivars. Yellow onions have the highest total flavonoid content, an amount 11 times higher than in white onions. Red onions have considerable content of anthocyanin pigments; with at least 25 different compounds identified representing compounds identified representing 10% of total flavonoid content **[12]**. The nutritional quality obtained in this study is in agreement with the values reported for onion bulbs by Holland *et al.*, (1991) and Atanda (2015) **[11,17]**. The significant differences in the nutritional and phytochemical contents of onion bulbs and leaves might be due to genetic differences among the cultivars examined. The lower nutritional values obtained for rain-fed onion in April and August are in agreement with the earlier findings of Ansari (2007) **[13]** who attributed poor performance during the raining season to the excessive rainfall and pest and diseases.

Conclusion and Recommendation

In conclusion, karibou variety and November planting date exhibited significant higher nutritional and phytochemical qualities, and therefore can be recommended for the high nutritional values of onion in Ogbomoso, southwestern agroecological zone Nigeria.

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