Growth and fruit yield responses and proximate composition of hot pepper (*Capsicum annuum* L; Rodo Variety) to potassium fertilizer application at Ado-Ekiti, Nigeria

Abstract

Potassium (K) application, is necessary to maximize crop yield and quality, by correcting the plant, soil and environmental factors limiting K availability. The effects of 0, 30, 60 and 90 kg K_2O ha^{-1}were studied on hot pepper (*Capsicum annuum* L; *Atarodo* variety) in 2014 and 2015 on the Teaching and Research Farm, Ekiti State University, Ado-Ekiti in a Randomized Complete Block Design with four replications Each K rate was mixed with 75 kg N and 25 kg P_2O_5 ha^{-1} and applied 2 weeks after transplanting 5-week old seedlings spaced 60cm×40 cm apart. Data of growth parameters were collected at 2 weeks after treatment (WAT) and at 2-weeks interval till 10 WAT, number and weight of ripe fruits and fruit proximate composition. The plant height, number of leaves, leaf area and dry matter increased with age and K rates to highest values at 10 WAT and 90 kg K_2O ha^{-1} in both years. The number of fruits, fruit and seed yield ha^{-1}, fruit size, fruit length and breadth and pericarp thickness increased linearly from the control to the highest values at 90 kg K_2O ha^{-1}.The number of fruits and yield at 90 kg K_2O ha^{-1} were 1.253×10^6, 14.24 t ha^{-1}; and 3.73×10^6, 14.94 t ha^{-1}in 2014 and 2015, respectively but 60 kg K_2O ha^{-1}gave the highest agronomic efficiency. Fruit moisture content increased slightly and would not predispose fruits to deterioration while crude protein and fat, carbohydrate and ash contents, vitamin C and mineral nutrients increased significantly making K application necessary to balance the fertilizer protocol for optimum hot pepper production.

Key words: Hot pepper, potassium, growth, ripe fruits, agronomic efficiency, proximate composition, mineral nutrients

Introduction

Pepper (*Capsicum* spp.) belongs to the family Solanaceae,) is a popular spice worldwide and whose use in Nigeria as condiment in all local soups, stew and sauces has no cultural and religious barriers (FAO, 2012). It is a high-valued fruit vegetable with great demand due to the characteristic pungency, pleasant flavour and colour (Umesh, 2008). The nutraceutical values are attributed to the antioxidant properties of the ascorbic acid, carotenoids and phenolic compounds contained, which make daily pepper intake a health-promoting factor in the prevention of chronic cancer, diabetes, cardio-vascular diseases and liver cirrhosis (Navaro *et al*., 2006) and control of prostate cancer, rated as the second biggest men's killer in Africa (Nwose, 2009).

The improved technologies adopted in the field-grown and greenhouse systems in Europe and North America produced the high fruit yields and quality which had ensured the dominance of sweet pepper in the world pepper industry. This is unlike the hot pepper (*Capsicum annuum* L, *C. frutescens* L) widely cultivated in Africa as a traditional vegetable or spice (Grubben and El-Tahir, 2004) in the multiple cropping systems that characterize the homestead gardens and outlying fields. The two pepper species cultivated in Nigeria occur in two fruit forms each and are known by various local names (1) *Capsicum annuum*: *Rodo*- round and wrinkled fruit shape, hot; and *Tatase* or *Tatasai*-bell hape, mildly hot and (2) *Capsicum frutescens*: *Sombo*- long slim with pointed tip (cayenne), hot and *Ata wewe* or *Wewe*- short, small 'bird eye', very hot (Olufolaji and Denton, 2000). Out of the cultivars, *rodo* shows the widest adaptation to all the agro-ecological zones of Nigeria but the cultivation in Ekiti State is characterized by low average yield of 2.64 t ha^{-1} because of local landraces grown (Oluleye *et al*., 2016) compared to average national productivity of 3.85 t.ha^{-1} in 2009 (FMARD, 2010) and the average global yield of 13.4 t ha^{-1} (Grubben and El-Tahir, 2004). The constraints to high pepper yield are the use of low-yielding genotypes, small-scale level of production, multiple cropping and poor adoption of improved technologies, especially nutrient management (Aliyu, 2000; Olarewaju and Showemimo, 2003) because of reliance on nutrients recycled in natural fallow re-growths or supplied from household refuse and manures. Thus, high-yield production systems based on nutrient supply from fertilizers should be adopted to ensure greater hot pepper output.

Hot pepper is grown as an annual crop, which requires the continuous supply of balanced nutrients to maintain rapid growth during the short life-cycle, produce high fruit yields of good quality and maximize profit. Hedge (1997) estimated the daily nutrient requirement of pepper as 5 kg N, 2 kg P_2O_5 and 6 kg K_2O and with uptake to produce 1.0 t ha^{-1} fresh fruits as 3.0-3.5 kg N, 0.8-1.0 kg P_2O_5 and 5.0-6.0 kg K_2O ha^{-1}and barring other constraints, nutrient uptake is closely related to the fruit yield. The largest requirement of K probably relates to the roles in maintaining osmotic potential of cells and turgidity in plants; regulating the opening and closure conditions of stomata; water uptake from the soil, water retention in the plant and long distance transport of water in the xylem and photosynthates in the phloem, cell extension and crop quality as its adequate supply makes cell walls thicker thereby improving plant resistance to lodging, pests and diseases and increasing the shelf-life (Marschner, 2012). The adequate K supply has now been linked to the synthesis of simple sugars, starch, protein and pigments or carotenoids; nitrate reduction; cell division; and balancing acid sugar ratio in fruits; uptake and transport of nitrate towards the aerial parts of the plant, which, in turn, enhances the activities of nitrate-assimilating enzymes and so improves the dry matter yields (Anjana and Iqbal, 2009).

Lester *et al*. (2006) observed that K may be abundant in many soils but the bulk is unavailable to plants because the plant-available K (dissolved or solution K and exchangeable K) poolis much smaller compared to the mineral K and non-exchangeable K (90-98% and 1-10% of total K respectively). The available K content depends on the chemical composition of the parent rocks and parent materials, mineralogy of the sand and silt fractions, degree of weathering and leaching as influenced by the prevailing climatic sssconditions such that it is lower in heavily weathered, red and sandy lateritic soils in the humid areas (Singh and Trehan, 2008; FFD, 2012). In south-west Nigeria, the soils derived from igneous and metamorphic (basement complex) rocks contain higher total K than those from sedimentary parent materials and the contents appear higher in soils under savannah vegetation than in the forest regions (Anon, 2006). The soils whose parent materials are derived from basement complex rocks and contain a lot of K minerals (mica, feldspars) do not show widespread K deficiency since plant roots under the bush fallow regrowth can reach the weathered rocks to absorb K for accumulation in surface biomass which on death return to the soil solution (Adepetu *et al*., 2014). However, with the application of nitrogen (N) and P phosphorus (P) fertilizers under increased cropping intensities and continuous cultivation, K deficiencies are spreading which make the inclusion of K fertilizers in the fertilization protocol necessary for crop production.

Most of the experiments on the nutritional requirements of fruit vegetables concern treatments that consisted of compound NPK fertilizer rates and combined N+P, N+K and NPK+PM (Olarewaju and Isma, 1990) while there were information on single nutrients for pepper production concerns N (Olanrewaju and Isma, 1990; Ekwu and Okporie, 2002; Ayodele *et al*., 2015) and P (Aliyu and Olarewaju, 1996; Alabi, 2006; Alabi and Ayodele, 2019). There is no information on the responses of hot pepper to K fertilization. Besides, the main K fertilizer- muriate of potash - is scarce, costly and requires huge financial resources for importation and use in bulk blending of compound NPK fertilizers such that the appropriate rate to apply should be determined to avoid wastage of the K fertilizer. This study was carried out to determine the rate of K that will produce the best growth and optimum fruit yield and quality, mineral content and proximate composition of field-grown hot pepper (*Atarodo*) in Ado-Ekiti, Nigeria.

Materials and Methods

The experiment was carried out at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti (long. 5º13′ E and lat. 7º 13′ N) during the rainy seasons of 2014 and 2015. The experimental sites were 2-3 year fallow plots infested with Mexican sunflower (*Tithonia diversifolia*), Siam weed (*Chromolaena odorata*) and guinea grass (*Panicum maximum*). The plots were ploughed, harrowed and fairly level portions, measuring 17×15 m were marked out and divided into 2.8×2.4 m sub-plots separated by 1 m wide paths. In 2014, the soil was a moderately acid sandy loam with low organic matter, total N, available P and exchangeable cations but a sandy clay loam in 2015 with slightly higher values of the fertility indices (Alabi and Ayodele, 2019).

Hot pepper (*Atarodo* variety, NHCa (R) 429) seeds obtained from National Horticultural Research Institute, Ibadan were sown in seed trays and the emerged seedlings were nursed for 5 weeks. The seedlings were transplanted at 60×40 cm spacing into plots allotted to the K rate treatments: 0, 30, 60 and 90 kg K_2O ha^{-1} in four replicates arranged as randomized complete block design. Each K rate was mixed with 50 kg N and 25 kg P_2O_5 ha^{-1} as urea and single superphosphate respectively and applied in bands 6-8 cm away from each seedling at 2 weeks after transplanting while the second half of N (25 kg N ha^{-1}) was applied at first fruit set. The plots were weeded manually as necessary.

Data collection on growth parameters commenced 2 weeks after treatment (WAT) from randomly selected plants and continued at 2-week intervals until 10 WAT. Ripe fruits were hand-picked at 5-day intervals, counted and weighed for 10 harvests. Fruits were selected randomly from each treatment to measure length and breadth, and sliced open to determine the pericarp thickness and seed yield. The agronomic efficiency of K application was calculated with the formula:

Potassium Agronomic Efficiency = $Y_F - Y_C / QK$

Where YF = Fruit yield with fertilizer, t ha^{-1}
YC = Fruit yield without fertilizer, t ha^{-1}
QK = Quantity of K applied, kg K_2O ha^{-1}

Ripe fruits were selected from each treatment at the peak harvest for proximate analysis using the methods described in AOAC (2005). The samples obtained during dry ashing were dissolved in 10% HCl solution and filtered for determination of total P with the vanado-molybdate yellow method, K and Na were measured by flame photometry while Ca and Mg were determined by atomic absorption spectrophotometer.

The data were subjected to statistical analysis using the Linear Model of the SAS Institute (SAS, 1995) package. The statistical inferences were drawn based on F (variance ratio) value and the treatment means separated.

Results

The effects of K application on the growth parameters of hot pepper are shown in Table 1. In the two years, all the growth parameters increased with age of the pepper plants and most of the development occurred between 4 and 8 WAT but the highest values were at 10 WAT. The K application significantly (P=0.05) increased the parameters from the control (0 kg K_2O ha^{-1}) to the highest values at 90 kg K_2O ha^{-1} in each sampling time such that plant height, number of leaves and leaf area were 45.48 cm, 123.43 and 46.98 cm^2; and 34.50, 138.23 and 44.48 cm2 in 2014 and 2015 respectively. The dry matter yields of hot pepper increased with age and at each sampling time, K application significantly increased the root, stem and leaf dry weights and the trend was similar in 2014 and 2015 (Table 2).

At 10 WAT, the highest leaf, stem and root dry weights were obtained at 90 kg K_2O ha^{-1} while the control treatment gave the least values.

Table 3 shows the effects of K application rates on the number of fruits, fruit yield and seed yield, fruit size, fruit length and breadth and pericarp thickness. Pepper showed significant responses to K application in all the yield parameters and the values increased from the least in the control treatment to the highest at 90 kg K_2O ha^{-1}. The highest number of fruits and fruit yield produced at 90 kg K_2O ha^{-1} were 1.253×10^6 and 14.24 t ha^{-1}; and 3.73×10^6 and 14.94 t ha^{-1} in 2014 and 2015 respectively. The control treatment gave the least fruit size, fruit length and breadth, pericarp thickness and seed yield which increased to the highest values of the respective parameters in the two years.

Table 4 shows the agronomic efficiency of K application to yield attributes of hot pepper. The calculations were based on number of fruits, fruit and seed yield ha^{-1}. The agronomic efficiency increased from 30 kg K_2O to the highest at 60 kg K_2O and declined at 90 kg K_2O ha^{-1} in both years. The highest values at 60 kg K_2O ha^{-1} rate were 5,617 and 8,333 fruits, 62.52 and 33.40 kg fruit and 1.287 and 3.140 kg seed yield kg K_2O ha^{-1}in 2014 and 2015 respectively.

Table 1: The effects of K application on the growth of hot pepper

	Weeks after Treatment

Treatments	2	4	6	8	10
Potassium (K gha^{-1})			**Plant height (cm)**		
0	14.27d	18.73d	23.20d	3.23d	33.85d
30	16.73c	22.10c	26.15c	42.68c	43.13c
	17.45b	23.60b	27.65b	43.50b	44.18b
60					
90	17.93a	24.08a	32.45a	44.55a	45.48a
S.E	0.05	0.05	0.05	0.06	0.08
			Numbers of leaves Plant^{-1}		
0	9.38c	28.13d	58.93d	81.65d	92.52d
30	11.55b	34.68c	74.50c	99.48c	119.35c
60	12.95a	38.15b	78.13b	110.13b	121.70b
90	13.01a	46.55a	82.45a	122.85	123.43a
S.E	0.05	0.06	0.62	0.7	
			Leaf Area Plant^{-1} (Cm2)		
0	11.38	17.25d	30.15d	36.43d	36.18d
30	18.53c	19.33c	31.55c	41.55c	41.85c
60	19.78b	20.92b	35.96b	44.20b	44.53b
90	20.13a	23.76a	38.93a	46.25a	46.98a
S.E	0.04	0.05	0.12	0.15	0.13
2015			**Plant height (cm)**		
0	15.02 d	17.50 d	24.05 d	33.72 d	34.50d
30	16.47 c	21.95 c	26.40 c	42.47 c	44.55c
60	17.75b	22.95b	28.93b	44.65b	45.08d
90	17.98a	24.13a	32.85a	46.45a	47.86a
S.E	0.09	0.06	0.06	0.08	0.09
			Number of leaves Plant^{-1}		
0	9.25dc	31.42d	62.33d	94.23d	102.13d
30	10.47b	36.23c	75.82c	101.50c	126.43c
60	12.98a	44.83b	80.13b	121.55b	130.23b
90	13.20a	47.65	83.24a	130.92a	138.23a

S.E	0.08	0.31	0.20	1.02	1.07
	Leaf Area Plant $^{-1}$ (Cm^2)				
0	13.20d	17.55d	27.15d	35.18d	35.93d
30	16.40c	19.75c	31.23c	37.35c	38.23c
60	18.53	20.70b	35.15b	40.85b	42.35b
90	21.15a	22.43a	37.30a	44.25a	44.48a
S.E	0.09	0.07	0.14	0.17	0.16

Means followed by the same letter in each column are not significantly different at (P=0.05)

Table 2. The effects of K application on the dry matter yield of hot pepper

	Weeks after Treatment				
Treatments	**2**	**4**	**6**	**8**	**10**
Potassium (K gha^{-1})	**Root dry Weight Plant $^{-1}$ (gm)**				
0	0.26d	0.44d	0.96d	1.22d	1.34d
30	0.42c	0.051c	1.28c	1.54c	2.02c
60	0.56b	0.68b	1.56b	1.92b	2.46b
90	0.64a	0.84a	1.95a	2.46a	2.64a
S.E	0.02	0.04	0.042	0.051	0.052
	Stem dry weight Plant^{-1} (gm)				
0	0.70d	1.54d	1.86d	2.14d	2.43d
30	1.04c	2.16c	2.36c	2.94c	3.72c
60	1.24b	2.33b	2.84b	3.71b	4.31b
90	1.38a	2.86a	3.64a	5.06a	45.44a
S.E	0.040	0.040	0.08	0.120	0.122
	Leave dry Weight Plant^{-1}(gm)				
0	2.08d	3.36d	6.63d	7.12d	6.84d
30	3.12c	3.84c	7.56c	8.48c	8.56c
60	3.63b	4.29b	8.59c	9.32b	9.23b
90	4.01a	4.72a	9.88a	10.15a	10.36a

S.E	0.025	0.029	0.05	0.044	0.045
2015			**Root dry Weight Plant $^{-1}$**		
0	0.21c	0.24d	0.48d	1.13d	1.27d
30	0.32b	0.43c	0.89c	1.75c	1.82c
60	0.34a	0.56b	1.02b	2.09b	2.26b
90	0.41a	0.72a	1.57a	2.28a	2.45a
S.E	0.02	0.031	0.024	0.032	0.034
			Stem dry weight Plant $^{-1}$ (9m)		
0	0.79c	0.82d	1.54d	2.71d	2.84d
30	1.03b	1.63c	2.51c	3.38c	3.67c
60	1.06a	1.71b	2.63b	4.02b	4.24b
90	1.12a	1.84a	3.24a	5.26a	5.32a
S.E	0.02	0.033	0.31	0.03	0.04
	Leaf dry Weight Plant $^{-1}$(gm)				
0	0.26c	0.27d	1.38d	2.31d	2.08d
30	0.48b	0.51c	2.49c	3.72c	2.02c
60	0.75a	0.68b	2.66b	4.09b	4.32b
90	0.77a	0.78a	2.91a	4.35a	4.66a
S.E	0.04	0.03	0.043	0.042	0.044c

Means followed by the same letter in each column are not significantly different at (P=0.05)

Table 3. The effects of K application rates on fruit yield and fruit parameters of hot pepper

Means followed by the same letters in each column are not significantly different (P = 0.05

Treatment(kg) (K_2O ha-1)	Numbers of fruits ha-1 ($X10^6$)	Fruit yield (t ha-1)	Fruit Size	Fruit length (cm)	Fruit breath (cm)	Pericarp thickness (cm)	Seed yield (K_2O ha-1)
2014							
0	0.803d	9.13d	3.43d	3.75d	2.13d	0.020d	170.31d
30	0.9932c	10.60c	3.85c	4.06c	2.22c	0.26c	201.39c
60	1.140b	12.88b	4.73b	4.25b	2.31b	0.31b	247.50b
90	1.253a	14.24a	4.91a	4.30a	2.35a	0.35a	275.76a
LSD	0.003	0.08	0.04	0.032	0.003	0.003	0.18
2015							
0	3.02d	12.06d	3.55d	4.02d	2.08d	0.26d	627.37d
30	3.20c	12.79c	4.53c	4.21c	2.25c	0.30c	716.22c
60	3.52b	14.06b	4.61b	4.30b	2.33b	0.34b	795.74b
90	3.73a	14.94a	4.75a	4.36a	2.39a	0.38a	846.92a

Table 4: Agronomic efficiency of K application determined for yield parameters of hot peppers.

K_2O kg ha $^{-1}$	Number of fruits kg^{-1}	Fruit yield kg ha^{-1}	Seed yield kg ha $^{-1}$
0			
30	4.30	49.0	1.036
60	5617	6.25	1.287
90	5,000	56.8	1.172
2015			
30	6.000	24.3	2.962
60	8,333	33.3	3.140
90	7,889	32.0	2,795

The effects of K application on the proximate composition and mineral contents of hot pepper fruits are shown in Table 5. The moisture content was 82.04 and 82.11% in the control and increased to 82.44 and 82.46% at 90 kg K_2O ha^{-1} in 2014 and 2015 respectively but which did not differ from the moisture content at 60 kg K_2O ha^{-1}. The ash and fat contents increased from the least values at 1.26 and 3.19% in the control to the highest values of 1.41 and 3.29% at 90 kg K_2O ha^{-1} in 2014 but which did not differ from 60 kg K_2O ha^{-1}. In2015, the ash and fat increased from 1.41 and 3.13% in the control to the highest values of 1.48 and 3.28% at 90 kg K_2O ha^{-1}.

Table 5: The effects of K application on Proximate Composition and Nutrient Contents of ripe hot pepper fruits.

	Rate of application ($k_2okg\ h^{a-1}$)				
Property	**0**	**30**	**60**	**90**	**LSD**
2014					
Moisture Content (%)	82.04b	82.11b	82.41a	82.44a	0.22
Ash (%)	1.26a	1.32ab	1.34a	1.41a	0.09
Fat (%)	3.19a	3.21a	3.34a	1.41a	0.12
Crude Protein (%)	4.75d	5.06c	5.50b	5.93a	0.06
Crude fibre (%)	4.20a	3.32b	2.25c	1.22d	0.05
Carbohydrate (%)	4.56d	4.94c	5.26b	5.61a	0.07
Vitamin C (mg100g-1)	104.36d	128.94c	142.22b	149.46a	0.05
N (%)	0.76d	0.81c	0.88b	0.95a	0.03
P(mg Kg^{-1})	80.60d	90.43c	91.98b	93.28a	0.02
K(mg Kg^{-1})	2062.36d	2087.25c	2142.79b	2170.69a	0.06
Ca(mg Kg^{-1})	114.03d	114.23c	115.53b	118.35a	0.01
Mg(mg Kg^{-1})	1022.73d	1057.95c	1082.14b	1143.94	0.02
Na(mg Kg^{-1})	87.75	90.43	91.98	93.28	0.02
2015					
Moisture Content (%)	82.11d	82.24c	82.40b	89.46a	0.08
Ash (%)	1.41a	1.41a	1.43a	1.48a	0.06
Fat (%)	3.13c	3.15b	3.17b	3.28a	0.04
Crude Protein (%)	4.81d	5.19c	5.39b	6.13a	0.04
Crude fibre (%)	3.91a	3.06b	2.28c	1.04d	0.05
Carbohydrate (%)	4.61d	4.98c	5.33d	5.61a	0.15
Vitamin C (mg100g-1))	112.77d	132.26c	146.32b	153.24a	0.5
N(%)	100.76d	101.42c	102.23b	102.76a	0.03
P(mg Kg^{-1})	0.77d	0.83c	0.86b	0.98a	2.37
K(mg Kg^{-1})	82.76d	92.45c	92.95b	92.16a	1.00
Ca(mg Kg^{-1})	117.44d	117.96c	118.35b	120.87a	4.01
Mg(mg Kg^{-1})	1023.02d	1083.16c	1089.79b	1144.123	3.38
Na(mg Kg^{-1})	90.70d	92.84c	94.83b	96.449	0.007

Means followed by the same letter in each column are not significantly different at (P=0.05)

The crude protein and carbohydrate had the least values in the control treatments and increased significantly to the highest values at 90 kg K_2O ha^{-1} rate while the crude fibre decreased from the control to the 90 kg K_2O ha^{-1}in both years. The vitamin C content was least in the control and increased to the highest values of 149.46 and 153.24 mg 100 g^{-1} at 90 kg K_2O ha^{-1} in 2014 and 2015 respectively. The total minerals (N, P, K, Ca, Mg and Na) increased form the least values in the control to the highest values at 90 kg K_2O ha^{-1} which differed significantly from the lower rates in both years.

Discussion

In this study, K application enhanced the growth performance of hot pepper in terms of taller plants with more branches and leaves, larger leaf areas and dry matter segmented into leaf, stem and root. The exchangeable K contents of the soils in the experimental sites are lower than 0.2 cmol kg^{-1} established as the critical level for arable crops in Nigeria (Adepetu *et al*., 2014) and provide the basis for the significant responses in the two years. The hot pepper showed linear responses to K application up till 90 kg K_2O ha^{-1} which gave the highest values of the growth parameters, dry matter yield and fruit yield indices. Johnson and Decoteau (1996) had noted that plant biomass, number of fruits and fruit weight plant^{-1} in pepper increased linearly with K rates and the highest fruit yield, as an outcome of the maximum number of fruits harvested, reflected the contribution of adequate soil K from the applied K to the translocation of larger amounts of assimilates to the respective plant parts up to maturity thereby promoting vegetative and reproductive development. The increase in biomass, number of fruits and weight and other fruit parameters due to increase in K application rates was attributed to the roles played by K in physiological and biochemical processes such as cell division and elongation and metabolism of carbohydrate and protein compounds in the plants (Hsiao and Läuchli, 1986). El-Masry *et al*. (2000) indicated that 90 kg K_2O ha^{-1}rate ensured adequate K in the soil nutrient pool and availability of other nutrients which promote vegetative growth, flower development and early fruit formation.

The trend of growth and yield responses was similar in the two years but the values of the parameters at the individual K levels were higher in 2015 which could be attributed to better amount and distribution of rainfall which ensured adequate soil moisture, solubility of applied fertilizers and balanced supply of nutrients, especially K, and extended the duration of fruit formation and harvesting. Although the responses of all fruit yield parameters were linear up to the maximum at 90 kg K_2O ha^{-1}, the K agronomic efficiency increased but to the highest values at 60 kg K_2O ha^{-1}. This is an indication of adequate amounts of K being provided in the soil solution at 60 kg K_2O ha^{-1}such that further K addition became less efficient and more nutrients would be vulnerable to leaching especially under regimes of high rainfall and runoff by erosion.

The fruit quality parameters (length and breadth, average fruit size, pericarp thickness) were best at 90 kg K_2O ha^{-1}which make K application an agronomic practice to improve the fruit yield and quality of hot pepper. The other fruit quality characteristics to be improved relate to the nutritive values in terms of proximate composition and mineral contents. The fruit moisture content is germane to assessing the nutritive value, ease of processing, packaging and shelf life. The moisture content takes the larger percentage of *atarodo* hot pepper and was 82.04 and 82.11% without K application but increased slightly by about 0.45% at 90 kg K_2O ha^{-1}in the two years which exceed 74% reported in fresh hot pepper samples (Grubben and El-Tahir, 2004). **Table 5:** The increase in water content was associated with the effects of K in improving the fruit size in pepper (Abu-Zahra, 2001) due to thicker fleshy mesocarp from more efficient sink functions, higher number and bigger size of individual cells(Gill and Thakur, 1994). However, the high moisture content up till 90 kg K_2O ha^{-1} is not an indication that the pepper fruits will be vulnerable to rapid deterioration from microbial contamination but emphasizes the need for prompt processing to improve the quality and prolong the shelf-life of hot pepper products (Dashak *et al*., 2001).

The crude protein content increased with K application and the levels show that hot pepper would be an important component of human diets, especially as this relates to the presence of capsaicin and allicine which are proteinous metabolites (Marschner, 2012). The carbohydrate increased with K application to the highest level at 90 kg K_2O ha^{-1} which would not qualify hot pepper as energy food but as spices for seasoning and colouring food (Roy *et al*., 2011).

The crude fat increased with K application but with the contents, hot pepper would not be considered as an oil seed, though the oil can be extracted as an essential oil (Okwu and Nnadi, 2008). The crude fibre declined with K application but this would not be a threat in the human diet but an indication that it can be used as adjuncts or additives to other foods because pepper is rarely consumed as a dish, in isolation. The ash content is low but increased with K application which indicates the low inorganic minerals in hot pepper fruits. Thus, N, P, K, Ca, Mg and Na increased with K application to the highest values at 90 kg K_2O ha^{-1} and these minerals have important functions in human nutrition and health. The increase in vitamin C is related to the role adequate K supply plays in carbohydrate metabolism which has an existing relationship with the formation of ascorbic acid (Ananthi *et al*., 2004). The vitamin C has antioxidant properties which make the application of K to hot pepper a proper agronomic practice to improve the its health-promoting quality.

Conclusion

The *Atarodo* variety of hot pepper (*Capsicum annuum* L) is the most widely adapted to the agro-ecological zones of Nigeria but on which agronomic information, especially fertilizer use, is insufficient. This relates to the studies that emphasize N and P requirements to the exclusion of K needed to balance the nutrients in the soil for optimum growth and yield. The studies carried out at Ado-Ekiti in 2014 and 2015 showed that K application to hot pepper (*Atarodo*) showed significant increases in growth, fruit yield and fruit quality parameters, proximate composition and mineral nutrient contents up till 90 kg K_2O ha^{-1} in soils whose exchangeable K contents were below the established critical level for arable crops in Nigeria. The linear responses of the fruit yield parameters were to maximum at 90 kg K_2O ha^{-1} but the highest agronomic efficiency was at 60 kg K_2O ha^{-1}. Thus, further studies involving higher K rates and soil with different levels of exchangeable K would ascertain the actual K rate needed in the fertilizer protocol to recommend for hot pepper farmers.

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