Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2582-2845.7989

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2020) *8*(2), 8-15

Indian Journal of Pure & Applied Biosciences

Research Article

Evaluation of the Agronomic Performance of Onion Varieties in the Rainy and Dry Season in Northern Ivory Coast

Séraphin Konan[1*], Athur Affery[2], Edson Lezin Bomisso[3], Abdoulaye Bire[4] and Michel Zouzou[5]

[1]PhD Student, University Félix HOUPHOUËT-BOIGNY, African Excellence Center on Climate Change, Biodiversity and Sustainable Agriculture (CEA-CCBAD), Ivory Coast

[2, 3]Senior Scientist, University Félix HOUPHOUËT-BOIGNY, Laboratory of Vegetal Physiology, Ivory Coast

[4]Agricultural Engineer, National Rural Development Support Agency (ANADER)

[5]Profesor, University Félix HOUPHOUËT-BOIGNY, Laboratory of Vegetal Physiology, Ivory Coast

*Corresponding Author E-mail: phinokonan@gmail.com

Received: 7.02.2020 | Revised: 12.03.2020 | Accepted: 20.03.2020

ABSTRACT

Onion is a vegetable of great consumption in Côte d'Ivoire. However, it is only grown in the dry season and national production cannot meet the needs of the population. The objective of this study was to identify onion varieties adapted for production during the rainy season in northern Côte d'Ivoire. To better assess the performance of the varieties, trials were conducted in both the dry and rainy seasons. Six varieties were evaluated, including : Galmi Violet, Damani Violet, Safari, Karibou, Ares and Syng 8362. Measurements included plant survival rate after transplanting, growth parameters, flowering rate, production parameters and bulb quality parameters. In the dry season survival rates ranged from 95.64% to 97.56%. The yield of Galmi Violet was the highest (27.09 t/ha) and the lowest was noted at Safari (16.21 t/ha). In the rainy season, survival rates varied between 37.12% and 88.58% and yields varied between 3.19 t/ha and 23.15 t/ha. With the exception of Ares, all other varieties lost half their density. Ares was the most efficient with a total yield of 23.15 t/ha.

Keywords: *Onion, Varieties, Rainy season, Dry season, Adaptation, Ivory Coast*

INTRODUCTION

Onion (*Allium cepa* L.) is a herbaceous monocotyledon belonging to the family Amaryllidaceae (APG III, 2009). It is cultivated as a vegetable plant for its bulbs and leaves, which are basic ingredients for many culinary preparations in all regions of the world (Megroz & Baumgartner, 2000). In sub-Saharan Africa, onion cultivation is practiced in all countries and the sector is an important source of income for all those who engage in it (Cathala et al., 2003). However, except Niger and Burkina Faso, which produce quantities that exceed domestic demand, the production of other West African countries cannot meet national consumption needs (Tarchiani, 2013).

Cite this article: Konan, S., Affery, A., Bomisso, E.L., Bire, A., & Zouzou, M. (2020). Evaluation of the Agronomic Performance of Onion Varieties in the Rainy and Dry Season in Northern Ivory Coast, *Ind. J. Pure App. Biosci. 8*(2), 8-15. doi: http://dx.doi.org/10.18782/2582-2845.7989

In Ivory Coast, national onion production is between 5.000 and 7.500 tons/year, while the annual demand for onions is now estimated at over 100.000 tons. Due to this large difference between supply and demand, Ivory Coast is dependent on the external onion market for about 95% (Anonymous 1, 2014). In order to reduce Ivorian onion imports, SODEFEL (ex-Société de Développement pour la production de Fruits et Légumes) had initiated cultivation in the north of Ivory Coast in 1980. This action allowed the selection and extension of the Galmi violet, a Nigerian variety introduced in Côte d'Ivoire (Fondio et al., 2001). In the same vein, Silué et al. (2003) undertook to select other onion varieties adapted to northern Ivory Coast. Despite these actions and the constant supervision of producers by the National Rural Development Support Agency (ANADER) to increase onion production, it remains low. This low onion production in Ivory Coast is due to climatic conditions that limit cultivation essentially in the north (Silué et al., 2003). Moreover, it can be explained by the fact that onion production is almost entirely in the dry season (Ali et al., 2018). To increase Ivorian onion production, one possibility would be to extend the production period in the rainy season with varieties that are adapted to it. The objective of this study is to identify high-yielding onion varieties adapted for production during the rainy season in northern Ivory Coast.

MATERIEL ET METHODES

Study site and vegetal material

The experiments were carried out on the plot of land of the National Rural Development Support Agency (ANADER), located in Ferkessédougou (9°62'63 north latitude and 5°32'72 west longitude), in the north of Côte d'Ivoire. The department of Ferkessédougou is subject to a monomodal rainfall regime, covering the period from May to October and a dry season from November to April. The dry season is characterized between December and February by a cool and dry wind, the harmattan. The climatic data (rainfall, relative humidity, minimum and maximum temperature, exposure time and photoperiod) recorded during the experiments are shown in Table 1. The soil texture is predominantly sandy with a pH of 6.5.

The plant material studied consisted of six varieties of onion which are: Violet of Galmi (VDG) Violet of Damani (VDD), Safari (SAF), Karibou (KAR), Ares and Syng 8362 (SYNG).

Table 1: Climatic data recorded during the experiments

Months	Rainfall (mm)	Relative humidity (%)	Temperature (°C)		sunshine duration (hour)	Photoperiod (hour)
			Mini	Maxi		
June	127,3	75,7	22,3	31,53	209	12,7
July	165,9	81,9	22,16	29,93	166	12,6
August	320,3	83,7	21,8	29,23	156	12,4
September	298,8	85,9	21,6	30,06	195	12,2
October	86,2	69,2	21,9	32,8	237	11,9
November	3,7	57,7	21,66	34,03	264	11,7
December	0	30,2	18,6	33,1	288	11,6
January	0	24,5	19	34,3	292	11,7
February	8,8	30,4	22,4	36,3	259	11,8
Mars	32,64	48,2	24,1	37,3	251	12,1
April	80,38	55,4	24,4	35,8	244	12,3

Conduct of trials and agronomic practices

The rainy season test was conducted from June 2018 to November 2018 and the dry season test was conducted from November 2018 to April 2019. The production method used was transplanting survival nursery seeding. The nurseries were set up in beds of 2 m^2 in area according to a row seeding. The 45-day old plants were then transplanted into 6 m^2 elementary plots in a fully randomized Fisher block system with four replicates. The transplanting geometry was 15 cm between rows and 10 cm between plants on a single row. Planting density was 50 plants/m^2, or 500.000 plants/ha. Before nursery sowing and transplanting, the beds were disinfected with Thioral, a mixture of insecticide and fungicide. Fertilizer NPK 18-24-24 was applied in the nursery (10 g/m²) and before transplanting (20 g/m²) as a background fertilizer. Urea 46% was applied in the nursery (5 g/m²) 25 days after sowing and in the field (20 g/m²) one month after transplanting. A second application of NPK 18-24-24 (20 g/m²) was made in the field, one month after the urea application. The frequency of watering in the field was three times a week in the dry season and on demand in the rainy season. Irrigation was stopped at the beginning of the plants' bedding down, corresponding to the bulb maturation phase. Phytosanitary treatments, weeding and hoeing were carried out on request. The bulbs were harvested according to the maturity of the varieties, after 70% of the plants had been laid down.

Observations and measures

Observations and measurements were made on plant survival after transplanting, growth parameters (plant height, number of leaves emitted per plant and bulbing index), production parameters (bulb rot rate at harvest, total yield, marketable yield, average bulb weight, bulb size), bulb quality parameters (dry matter and soluble dry extract content), flowering rate and length of crop cycle.

Plant survival rate after transplanting

Dead plants after transplanting were counted by variety and by repetition every 15 days for two months. The survival rate of each variety was then calculated by dividing the number of live plants by the number of transplanted plants, multiplied by 100.

Growth parameters

Growth parameters were assessed on 10 plants per variety per replant, randomly selected at 90 days after transplanting. Plant height was measured from the collar to the tip of the longest leaf, the number of leaves emitted was determined by counting. The bulbification index (IB) was determined by the ratio of the equational diameter of the bulb to the diameter at the collar of the plant. The plant has bulbified if IB is greater than or equal to 2 (Clark & Heath, 1962).

Production parameters

After harvesting and 4 days of sweating, the bulbs were counted by variety and then weighed per plot unit (6 m²). The average value established per variety corresponds to the gross yield. It is converted into t.ha-1. The average bulb weight was calculated per plot unit by dividing the weight of the bulbs by the number of organs harvested. The values are noted for averaging purposes. The number of rotten bulbs at harvest was counted by variety. Thus, for each variety, the rate of rot is calculated by dividing the number of rotten bulbs by the number of bulbs harvested, all multiplied by one hundred. In addition, for each variety, the bulbs were grouped according to size and expressed as a percentage. Size was determined according to the diameter (d) equation using a numerical calliper. Thus, the bulbs harvested were grouped as follows: C1 ($d \leq 30$ mm), C2 ($30 < d \leq 50$ mm), C3 ($50 < d \leq 70$ mm) and C4 (70 mm $< d$). Bulbs considered marketable are those of classes C2, C3 and C4, healthy. Thus, the marketable yield was calculated by subtracting the mass of C1 size bulbs and rotten bulbs from the gross yield.

Quality parameters

The dry matter content of the bulbs was determined by differential weighing in accordance with French standard NF V 03-707 (2000) on 5 bulbs per variety. To do this, 10 g of onion slices were weighed before and after being placed in an oven at 100 °C for 24 hours. The dry matter content was deducted by difference from the moisture content and then expressed as a percentage. The dry soluble extract expressed in degree Brix (° Brix) was also determined on five bulbs per variety with a digital refractometer type PR-1 Atago.

Flowering rate and length of crop cycle

For each variety, the flowering rate was obtained by dividing the number of flowering plants by the number of living plants, multiplied by 100. The length of the cropping cycle considered in this study is that from sowing to harvesting of the bulbs

Statistical analysis

All data collected were subjected to an analysis of variance (ANOVA) using STATISTICA 7.1 software. If there were significant differences between the means, the Newman-keuls multiple comparison test at the 5% threshold was used to classify them. The data expressed in percentages were transformed according to the formula arcsin√x/100 before being submitted for analysis.

RESULTATS ET DISCUSSION

Results of the variety effect on plant establishment, growth parameters and flowering rate under both climatic seasons are presented in Table 2. In the dry season, plant establishment percentage ranged from 95.64 % to 97.56 %. The differences observed were not significant ($P > 0.05$). Plant mortality was low in all varieties, which could be explained by their good adaptation to the environmental conditions of the dry season. Sensitive varieties would have been strongly affected. On the other hand, in rainfed crops, plant survival rates after transplanting ranged from 37.12 % (Safari) to 88.58 % (Ares). Analysis of variance showed a very significant varietal effect ($P < 0.001$). The varieties Violet of Galmi, Karibou, Safari, Violet of Damani and Syng 8362 recorded losses of more than half their density. Ali et al. (2018) obtained similar results when searching for onion varieties adapted for rainfed cultivation in central Burkina Faso. These varieties are reported to be very sensitive to excess moisture. Therefore, they do not seem to be adapted to rainfed cultivation. The survival rate of 88.58% for the Ares variety attests to its suitability for winter cultivation in Ivory Coast. This result confirms that of Anonyme (2014) obtained in Ghana.

As far as growth parameters are concerned, they were all influenced by the variety regardless of the climatic season ($P < 0.001$). In both the dry and rainy seasons, Ares was the highest with heights of 50.55 cm and 51.63 cm respectively. Safari was the shortest (40.30 cm in the dry season and 42.87 cm in the rainy season). In the dry season, the number of leaves issued by Ares (8.6), Karibou (8.4) and Violet de Galmi (8) were statistically equal and higher than those of the other varieties. The lowest numbers were noted in Syng 8362 (6.13) and Safari (6.53). In the rainy season, Ares produced more leaves (11.4) than the other varieties. Comparable results were obtained by Ahmed *et al*. (2013), who attributed the observed differences to genetic factors of the varieties used. Moreover, for each variety, the values of height and number of leaves emitted recorded in rainy season cultivation are relatively higher than those obtained in the dry season. These differences are thought to be related to environmental factors, including rainfall and temperature (Tesfay et al., 2011). In this regard, studies by Kumar et al. (2007) showed that onion growth parameters such as plant height, number of leaves and plant biomass have a positive correlation with the amount of water received. Also, according to Bosekeng (2012), the relative growth rate of leaves increases linearly with a temperature of up to 20°C. Beyond this threshold, the plant growth rate begins to decrease and when the temperature exceeds 26°C, growth ceases completely.

Bulbing index fluctuated between 5.47 (Violet of Galmi) and 4.08 (Safari) in the dry season and between 4.54 (Ares) and 3.16 (Safari) in the rainy season. In both the dry and wet seasons, the bulbing index (BI) of all varieties was above 2, the reference value of (Clark & Heath, 1962), which means that they all bulbified. However, with the exception of Ares, the bulbing index of the other varieties showed a major reduction during rainfed cultivation. This could be related to a reduction in photosynthetic activity due to low sunlight and high relative humidity. Indeed, the bulb is the organ of reserve of the photosynthetic assimilates. Under the effect of high atmospheric water vapour, the rate of photosynthesis and water uptake by plant roots is reduced due to partial or complete closure of stomata (Brewster, 2008). The good suitability of Ares is based on the fact that the performance of a variety depends on the interaction between its genetic factors and environmental conditions (Jilani & Ghafoor, 2003).

The flowering rate was also influenced by the variety but also by the season. The varieties flowering in summer cultivation are Ares (3.12 %), Safari (1.88 %), and Violet of Galmi (1.34 %). In the rainy season, only Ares (1.72 %) flowers. Onion flowering occurs at the end of the vegetative period following a period of vernalization (Aoba, 1960). Thus, cold stimulates the accumulation of cytokinin and gibberelin, altering the hormonal balance and leading the plant to develop a flowering stem (Rakhimbaev & Ol'Shaskaya, 1976). The absence of flowering observed in some varieties in both climatic seasons could mean that the length of vernalization required to stimulate flowering varies between varieties. Furthermore, Rouamba (1993) mentions that temperature is not the only factor inducing flowering in onions. He reports a genetic origin to explain the first year flowering observed in some onion varieties.

Table 2: Plant establishment, flowering rate and growth parameter in different onion varieties

Parameters	Seasons	Onion varieties evaluated						SEm ±	P-value
		VDG	KAR	SAF	ARES	VDD	SYNG		
% Plant establishment 60 DAT	DS	97.56 a	95.64 a	95.78 a	96.20 a	96.42 a	96.76 a	0.42	0.065
	RS	42.34 b	41.87 b	37.12 c	88.58 a	31.18 d	38.62 c	31.18	0.000
Plant height (cm)	DS	49.14 ab	41.38 d	40.30 e	50.55 a	42.67 c	41.75 d	4.00	0.000
	RS	49.72 b	45.03 c	42.87 e	51.63 a	44.49 dc	43.23 d	3.54	0.000
Number of leaves	DS	8.00 a	8.40 a	6.53 c	8.60 a	7.00 b	6.13 c	0.94	0.000
	RS	9.6 b	9.3 b	9.20 b	11.4 a	8.5 c	8.6 c	0.96	0.000
Bulbing index	DS	5.47 a	4.76 b	4.08 c	4.81 b	4.40 bc	4.84 b	0,43	0.000
	RS	3.86 b	3.48 cd	3.16 d	4.54 a	3.72 b	3.79 b	0.42	0.000
flowering rate (%)	DS	1.34 b	0 c	1.88 b	3.12 a	0 c	0 c	1.18	0.009
	RS	0 b	0 b	0 b	1.72 a	0 b	0 b	0.64	0.047

DAT : days after transplantation**, DS** : dry season **RS** : rainy season

For each parameter and per season, the means assigned the same letter are statistically identical to the 5% threshold. (Test of Newman-Keuls).

Table 3 presents the length of the cropping cycle of the onion varieties studied and the results for the production components during the two climatic seasons. The effect of the variety was significant on all parameters. The crop cycle of Syng 8362 was 145 days in the dry season compared to 150 days in the wet season. The crop cycle of the other varieties was 152 days in the dry season and 158 days in the wet season. This shows that Syng 8362 is the earliest variety. The differences in days observed between the crop cycles in the dry and rainy seasons are thought to be caused by the rains. According to Doorenbos and Kassam (1979), excessive irrigation during bulbing-out delays bulb ripening. Consequently, it prolongs the crop cycle.

The rate of bulb rot recorded at harvest differs between varieties. In the dry season, rot rates ranged from 0% for Ares to 1.24% for Syng 8362. In the wet season, values ranged from 0.72% for Ares to 5.20% for Syng 8362. Bulb rot is caused by excess water (Collin et al., 2004), which explains the increase in rates observed in the rainy season. The Syng 8382 variety that recorded more rot would be more susceptible to excess moisture.

Total bulb yields ranged from 16.21 t/ha to 27.09 t/ha in the dry season and from 3.19 t/ha to 23.15 t/ha in the wet season. The differences observed were very significant (P < 0.001). In the dry season, the highest gross yields were recorded for Galmi Violet and the lowest were recorded for Safari. The low yield recorded at Safari can be explained by its low productivity. In the rainy season, with the exception of Ares (23.15 t/ha), yields of the other varieties were very poor. They could not express their dry season performance. This can only be explained by the unsuitability of these varieties for rainfed cultivation.

In the dry season, the average bulb weights of Violet of Galmi (80.53 g), Syng 8362 (76.69 g) and Ares (76.35 g) were statistically equal and higher than those of the other varieties. The lowest value was noted in Safari (59.14 g). The majority of bulbs produced by Violet of Galmi (64.19%), Ares (59.91%), Syng 8362 (54.89%) and Karibou (54.38%) were of size C3 and those of Safari (56.49%) and Violet of Damani (51.64%) were of size C2. In rainfed cultivation, average bulb weights ranged from 24.50 g to 70.52 g. The average weight of Ares bulbs was the highest and the majority of its bulbs (57.38%) were C3 size. On the other hand, the majority of the bulbs produced by the other varieties were of size C2. The average bulb weights of the latter were much lower than those obtained in the dry season. The predominance of small-sized bulbs confirms the generally poor performance of these varieties in rainfed cultivation and explains their low yields.

After subtracting rotten bulbs and C1 size bulbs from the gross yield, marketable yields fluctuated between 15.11 t/ha (Safari) and 26.27 t/ha (Violet of Galmi) in the dry season and between 2.59 t/ha (Violet of Damani) and 22.43 t/ha (Ares) in the rainy season.

Newman

Table 3: Crop cycle of the onion varieties studied and the components of production in the dry and rainy seasons

Parameters	Seasons	Onions varieties evaluated						SEm ±	P-value
		VDG	KAR	SAF	ARES	VDD	SYNG		
Days to harvest after sowing	DS	152 a	152 a	152 a	152 a	152 a	145 b	2.60	0.038
	RS	158 a	158 a	158 a	158 a	158 a	150 b	2.98	0.044
Rotten bulb at harvest (%)	DS	0.93 b	0.82 b	0.68 b	0 c	0.76 b	1.24 a	0.37	0.012
	RS	4.14 a	4.86 a	3.22 ab	0.72 c	4.33 a	5.20 a	1.48	0.000
Total bulb yield (t/ha)	DS	27.09 a	21.29 bc	16.21 e	23.9 b	18.23 d	24.12 b	3.69	0.000
	RS	5.96 b	5.21 b	3.87 bc	23.15 a	3.19 bc	5.41 b	6.92	0.000
average bulb weight (g)	DS	80.53 a	67.31 b	59.14 c	76.35 a	61.74 c	76.69 a	8.05	0.000
	RS	32.47 b	30.03 b	26.18 c	70.52 a	24.50 c	31.65 b	15.74	0.000
C_1 (%)	DS	2.61 c	3.89 bc	6.83 a	2.50 c	4.47 b	2.17 c	1.6	0.039
	RS	5.18 bc	7.11 b	8.91 b	2.72 d	11.54 a	7.36 b	2.76	0.032
C_2 (%)	DS	30.75 e	40.10 c	56.49 a	35.62 d	51.64 ab	40.07 c	8.90	0.012
	RS	60.88 ab	64.57 a	66.58 a	39.90 c	65.92 a	63.56 a	9,27	0.028
C_3 (%)	DS	64.19 a	54.38 b	35.45 d	59.91 b	42.97 c	54.89 b	9.83	0.000
	RS	33.94 b	28.32 bc	24.51 dc	57.38 a	22.98 d	29.08 bc	11.57	0.00
C_4 (%)	DS	2.45 a	1.63 b	1.23 bc	1.97 b	0.94 c	2.87 a	0.66	0.000
	RS	0 a	0 a	0 a	0 a	0 a	0 a	0	1
Marketable yield (t/ha)	DS	26.27 a	20.51 bc	15.11 d	22.70 b	17.80 d	23.22 b	3.66	0.000
	RS	4.63 b	4.22 b	2.92 c	22.43 a	2.59 c	4.48 b	6.99	0.000

Table 4 shows the dry matter and soluble dry extract content of the bulbs of the different varieties evaluated. The effect of the variety was significant on these two quality parameters (P < 0.001). Overall, the varieties tested had low to medium dry matter and dry matter content in all seasons. In the dry season, the dry matter rates varied between 7.61% and 12.36% and the soluble dry matter rates varied between 12.45° Brix and 8.98° Brix. High values were noted in Violet of Galmi and the lowest values were recorded in Syng 8362. In rainfed cultivation, Violet de Galmi also recorded the highest values (12.24% and 12.25° Brix) and the lowest values were obtained at Syng 8362 (7.72% and 8.82° Brix). The results obtained corroborate those of Abhayawick et al. (2002) who reported that the dry matter content of onion bulbs normally varies between 7% and 18% of the fresh weight depending on the variety. This is a parameter that also deserves special attention from the point of view of storability. Indeed, there is a positive correlation between the general aptitude for conservation of the onion and the dry matter content of the bulbs (Assogba et al., 2007). A variety with a high dry matter content is a variety with a better bulb keeping quality. Onions with high dry matter content are firmer and therefore more resistant to damage caused by transport and handling (Silué et al., 2003).

Table 4: Onion varieties quality

Parameters	Seasons	Onions varieties evaluated						SEm±	P-value
		VDG	KAR	SAF	ARES	VDD	SYNG		
Dry matter of bulb (%)	DS	12.36 a	11.27 b	10.75 b	9.26 c	11.14 b	7.61 d	1.54	0.000
	RS	12.24 a	11.14 b	11.17 b	9.12 c	11.25 b	7.72 d	1.53	0.000
Soluble dry extract (° Brix)	DS	12.45 a	11.31 b	11.25 b	10.62 c	11.40 b	8.98 d	1.05	0.000
	RS	12.25 a	11.19 b	11.13 b	10.44 c	11.33 b	8.82 d	1.05	0.000

For each parameter and per season, the means assigned the same letter are statistically identical to the 5% threshold (Test of Newman-Keuls).

CONCLUSION

The results obtained from the trials showed that the performance of onion varieties differs according to the climatic seasons. In the dry season, Galmi's Violet variety performed best, surviving Syng 8362, Ares, Karibou. Safari and Damani Violet performed less well. In the rainy season, Ares was the only performer. Other varieties including Violet of Galmi performed less well. Thus, Ares is the best variety to grow for rainfed production in the north of Côte d'Ivoire. Other onion varieties suitable for rainfed cultivation must be identified in order to make several varieties available to producers.

REFERENCES

Abhayawick L., Laguerre J.C., Tauzin V., & Duquenoy A. (2002). Physical properties of three onion varieties as affected by the moisture content. *Journal of Food Engineering, 55,* 253 –262.

Ahmed A.K., Ali E.S., & Fathalla H.F. (2013). Effect of transplanting dates of some onion cultivars on vegetable growth, bulb yield and its quality, Egypt. *ESci Journal of Crop Production, 2*(3), 72-82.

Ali G., Somé K., Jeanne N., Mamoudou T., Mahamadou S., & Jérôme B. (2018). In field assessment of onion (*Allium cepa* L.) and shallot (*Allium cepa* var. *asculoni* cum) varieties for wintering culture in central Burkina Faso. *Int. J. Biol. Chem. Sci. 12*(4), 1836 -1850.

Anonyme. (2014). Diagnosis of the onion sector in Ivory Coast, Programme FLEX- FED/2013/324 233. 35 p. www.alimenterre.org/diagnostic-de-la-filiere-oignon-en-cote-d-ivoire. Accessed on 19/05/2018

Anonyme. (2014). Made leads cultivation of rainy season onion varieties. https://ghana-made.org/news/. Accessed on 08/02/2020

Aoba, T. (1960). The influence of the storage temperature for onion bulbs on their seed production. *Journal of Japanese*

Society of Horticultural Science, *29*, 135–141.

APG III. (2009). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. *Botanical Journal of the Linnean Society*, *161*(2), 105-121

French Standards Association (AFNOR), NF V03-707. (2000). Cereals and cereal products. Determination of moisture content. Practical reference method (Bulletin officiel n°2000-20).

Assogba-Komlan F., Bello S., & Baco M. (2007). Participatory field selection of a few short-day onion cultivars for Alibori county. *Bulletin de la Recherche Agronomique du Bénin*, *58*, 45-55.

Bosekeng G. (2012). Response of onion (*Allium cepa* L.) to sowing date and plant population. Thesis, Department of Soil, Crop and Climate Sciences, Faculty of Natural and Agricultural Sciences, University of the Free State. 156 p.

Brewster, J.L., (2008). Onions and other vegetable alliums. 2nd edn. *CAB International*, *Wallingford*, United Kingdom.

Cathala, M., Woin, N., & Essang, T. (2003). Onion, an increasing production in Sahelo-soudanian Africa; North Cameroon case. *Cahiers Agricultures*. *12*(4), 261-266.

Clark, J.E., & Heath, O.V. (1962). Studies in the physiology of onion plant. Investigation into the growth susbtance content of bulbing onions. *Journal of experimental Botany*, *13*, 249-277.

Collin, F., Brun, L., Jonis, M., Lelagadec, F., Lizot, J.F., Delmond, F., Broucqsault, L.M., Serpeille, A., & Laurent, E. (2004). Producing onion seeds in an agrobiological itinerary, technical data sheet, TECHN'ITAB, FNAMS, 4p.

Doorenbos, J., & Kassam, A. (1979). Yield response to water. FAO Irrigation and Drainage Paper 33, Rome.

Fondio, L., Kouamé, C., & Adjidji, H.A. (2001). In field and storage assessment of onion varieties (*Allium cepa* L.) at Ferkessédougou. *Agronomie africaine*. *13*(3), 113-130.

Jilani, M., & Ghafoor A. (2003). Screening of Local Onion Varieties for Bulb Formation. *International Journal of Agriculture and Biology*, *5*(2), 129-133.

Kumar, S., Imtiyaz, M., Kumar, A., & Singh, R. (2007). Response of onion (*Allium cepa* L.) to different levels of irrigation water. *Agricultural Water Management*, *89*, 161–166.

Mégroz, N., & Baumgartner, A.S. (2000). The onion, good to the taste and to the eye. With a magnifying glass, tabula n° 2. avril 4 p.

Rakhimbaev, I.R., & Ol'Shaskaya R.V. (1976). Dynamics of endogenous gibberellins during transition of garlic bulbs from dormancy to active growth. *Fisiologye Rasteii*, *23*, 76-79.

Rouamba, A. (1993). Joint analysis by agromorphological markers and allozymes of the genetic diversity of onion (*Allium cepa* L) populations in West Africa. Ph D Thesis of University Paris VI. 141 p

Silué, S., Fondio, L., Coulibaly, M., & Magein, H. (2003). Selection of Varieties Onion (*Allium cepa* L.) Adapted to the North of Ivory Coast. *Tropicultura*, *21*(3), 129-134.

Tesfay, S., Bertling, I., Odindo, A., Greenfield, P., & Workneh, T. (2011). Growth responses of tropical onion cultivars to photoperiod and temperature based on growing degree days. *Afr. J. Biotechnol*. *10*(71), 15875-15882

Zakari, A., Mahamadou, C., & Toudou, A. (2015). The effect of nitrogen on the ability of onion (*Allium cepa* L.) for conservation. *Int. J. Biol. Chem. Sci*. *9*(6), 2889 – 2896.