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Effects of Sowing Date on Growth and Production Parameters of the Rainfed onion Variety Ares in Central and Northern Ivory Coast

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Abstract

This study was conducted in central and northern Ivory Coast, precisely in Yamoussoukro and Ferkessédougou with the onion variety Ares. The objective was to determine the best planting dates for rainfed onion production in each of the agro-ecological zones. Thus, five sowing dates were tested. In Yamoussoukro, sowing was carried out on 01 May (D1), 15 May (D2), 01 June (D3), 15 June (D4) and 01 July. In Ferkessédougou, sowing was carried out on 3 May (D1), 17 May (D2), 3 June (D3), 17 June (D4) and 3 July (D5). The parameters evaluated were the survival rate of the plants after transplanting, the height of the plants, the number of leaves emitted from the plants, the rate of bulb rot at harvest, the total bulb yield and the weight per month of the bulbs. At the end of the trials, the best plant survival rates after transplanting were obtained for sowing dates D3 (94.38%), D4 (92.86%) and D2 (88.23%) in Yamoussoukro and sowing dates D1 (92.28%), D2 (91.1%) and D3 (89.15%) in Ferkessédougou, respectively. Plant height, number of leaves produced and average bulb weight decreased from early sowing to late sowing. Bulb rot rates were higher for early sowings and zero for late sowings. In Yamoussoukro, the best yields were obtained for sowing dates D3 (23.56 t/ha), D4 (22.42 t/ha) and D2 (20.27 t/ha). As for Ferkessedougou, the best yields were obtained for sowing dates D2 (23.72 t/ha) and D3 (23.15 t/ha).

Keywords: Ares onion; Sowing dates; Rainy season; Growth; Yield; Ivory Coast

Introduction

Onion (*Allium cepa* L.) is an Amaryllidaceae mainly grown for its leaves and bulbs for human consumption [1]. It is the second most cultivated vegetable in the world after tomato [2]. In sub-Saharan Africa, onions are grown in all countries and the sector is an important source of income for all those involved [3]. However, with the exception of Niger and Burkina Faso, which produce quantities that exceed domestic demand, production in other West African countries cannot meet domestic consumption needs [4]. In Ivory Coast, national onion production is between 5,000 and 7,500 tons/year, while annual demand for onions is now estimated at more than 100,000 tons. Because of this large difference between supply and demand, Ivory Coast is dependent on the external onion market for about 95% [5]. In order to reduce Ivorian onion imports, SODEFEL (ex-Development Company for the Production of Fruit and Vegetables) initiated the cultivation of onions in the north of Ivory Coast in 1980. This action allowed the selection and extension of the Galmi violet, a Nigerian variety introduced in Ivory Coast [6]. In the same vein, Silué et al. undertook to select other onion varieties adapted to northern Ivory Coast [7]. Currently, despite constant supervision of producers by the National Rural Development Support Agency (ANADER) to increase onion production, it remains low. Silué et al attribute this low onion production in Ivory Coast to climatic conditions that limit cultivation mainly in the north [7]. In addition, onion production is almost entirely in the dry season [8]. Thus, to increase Ivorian onion production, one possibility is to extend the growing period in the rainy season with varieties that are adapted to it. To this end, we have conducted experiments in northern and central Ivory Coast that have led to the selection of the Ares variety. The present study aims at determining the sowing dates for which the Ares onion variety shows the best agronomic performances in central and northern Ivory Coast during rainy season.

Materials and Methods

Study sites

The study was carried out in two locations which are: Yamoussoukro and Ferkessédougou. These two localities belong to different agro-ecological zones.

Yamoussoukro is located in central Ivory Coast at 6°48'36 North latitude and 5°17'44 West longitude. This zone is subject to a sub-equatorial climate, characterized by the alternation of two dry seasons and two rainy seasons. There is a long dry season from mid-November to March characterized by the harmattan between the months of December and January; a long rainy season from April to mid-July; a short dry season from mid-July to August punctuated by a few rains and a short rainy season from September to mid-November. Annual rainfall varies from 900 to 1,600 mm. The experiments were conducted on a village plot, located at 6°52'34 north latitude and 5°19'55 west longitude.

Ferkessédougou is located in the north of Ivory Coast, at 9°35'37 north latitude and 5°11'43 west longitude. The climate of the region is

tropical dry with two seasons: one dry, from November to April, characterized by the harmattan between December and February and the other humid, from May to October. The annual rainfall is around 1,200 mm. The experiments were conducted at the ANADER seed production station, located at 9°62'63 north latitude and 5°32'72 west longitude.

The climatic data recorded during the experiments and the physico-chemical parameters of the soils are given in Tables 1 and 2.

Sites	Months	Average rainfall (mm)	Average	Average air temperature (°C)		Average photoperiod (h)
			Relative humidity (%)	Mini	Maxi	
Yamoussoukro	May	108	81.1	23.7	32.9	12.4
	June	164.19	85.7	22.6	31.3	12.5
	July	138	86.3	22.2	29.8	12.4
	August	81	87	22.1	28.7	12.3
	September	88	86.8	22.5	30.7	12.1
	October	220	86.3	22.1	31.1	12
	November	18.79	83.1	22.6	32.8	11.8
	December	2.4	74.9	20.4	33.7	11.7
Ferkessédougou	May	103	70.2	23.7	33.4	12.5
	June	127.3	75.7	22.3	31.53	12.7
	July	165.9	81.9	22.16	29.93	12.6
	August	320.3	83.7	21.8	29.23	12.4
	September	298.8	85.9	21.6	30.06	12.2
	October	86.2	69.2	21.9	32.8	11.9
	November	3.7	57.7	21.66	34.03	11.7
	Décember	0	30.2	18.6	33.1	11.6

Table 1: Climatic data during the experimentations.

Physico-chemical properties	Sites	
	Yamoussoukro	Ferkessédougou
Clay (%)	9.18	8.5
Limon (%)	6.55	16.15
Sand (%)	84.27	75.35
pH_{eau}	6.4	6.5
Total carbon (%)	0.72	1.2
Total nitrogen (%)	0.07	0.11
C/N	10.28	10.9
MO (%)	1.25	2.06
P_{ass} (ppm)	50	79
K^+ (cmol.kg^{-1})	0.11	0.14
Ca^{2+} (cmol.kg^{-1})	4.16	3.27
Mg^{2+} (cmol.kg^{-1})	0.32	1.21
Na^+ (cmol.kg^{-1})	2.25	0.11
CEC (cmol.kg^{-1})	3.68	8.24

Table 2: Physio-chemical properties of soils at experimental sites.

Conduct of trials and agronomic practices

The trials were conducted from May 2019 to December 2019 with five different sowing dates (Table 3). The nurseries were set up at two-week intervals, in 2 m^2 beds with row seeding. The 45 days old seedlings were then transplanted in the field on 6 m^2 elementary plots with 4 replicates. The transplanting geometry was 15 cm between rows and 10 cm between plants on the same row. Planting density was 50 plants/m^2, i.e. 500000 plants/ha. Before sowing in the nursery and transplanting, 1 Kg/m^2 of compost and NPK 18-24-24 (10 g/m^2 in the nursery and 20 g/m^2 at transplanting) were applied as a background fertiliser. Then, the soils were disinfected with Thioral at a rate of 250 g/ha for the treatment. Urea 46% was brought to the nursery 25 days later at a rate of 5 g/m^2 and to the field at a rate of 20 g/m^2 one month after transplanting. A second application of NPK 18-24-24 was made in the field one month after the urea application at 20 g/m^2. Supplemental watering was carried out after 5 days of dry sequence until the beginning of the bedding of the plants, corresponding to the bulb maturation phase. Phytosanitary treatments and sarclo-binage were carried out on request. The bulbs were harvested after 70% of the plants had been laid down.

Sites	Sowing dates	Codes	Dates de repiquage
Yamoussoukro	01-May	D1	14-Jun
	15-May	D2	28-Jun
	01-Jun	D3	15-Jul
	15-Jun	D4	29-Jul
	01-Jun	D5	14-Aug
Ferkessédougou	03-May	D1	16-Jun
	17-May	D2	30-Jun
	03-Jun	D3	17-Jul
	17-Jun	D4	31-Jul
	03-Jul	D5	16-Aug

Table 3: Sowing and transplanting date.

Observations and measures

Observations and measurements were made on plant survival after transplanting, growth parameters (plant height, number of leaves emitted per plant) and production parameters (bulb rot rate at harvest, total yield, average bulb weight).

Plant survival rate after transplanting: Dead plants after transplanting were counted every 15 days for two months. Plant survival for each sowing date 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 replanting, 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.

Production parameters: After the harvest and 4 days of drying, the bulbs were counted and weighed per plot unit (6 m^2). The average value established corresponds to the gross yield. It is converted into tha^{-1}. The average bulb weight was calculated per plot unit by dividing the bulb weight by the number of organs harvested. The values are recorded for averaging purposes. For each sowing date, the number of rotten bulbs at harvest was counted. Thus, the decay rate is calculated by dividing the number of rotten bulbs by the number of bulbs harvested, all multiplied by one hundred.

Statistical analysis

All data collected were subjected to 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 $\arcsin\sqrt{x}/100$ before being submitted for analysis.

Results and Discussion

Plant survival rate after transplanting

At each study site, the effect of planting date was significant ($p<0.001$) on plant survival after transplanting. In Yamoussoukro, rates ranged from 78.51% to 94.38% (Table 4). The best survival rates were obtained respectively for sowing dates D3 (94.38%), D4 (92.86%) and D2 (88.23%). At Ferkessédougou, the values ranged from 71.21% to 92.28% (Table 5). In this locality, it was rather the sowing dates D1 (92.28%), D2 (91.1%) and D3 (89.15%) that gave the best plant survival rates after transplanting. These results could be explained by the fact that transplanting of plants from these planting dates took place during the months when rainfall is infrequent. The sowing date should therefore be chosen with the transplanting period in mind, as excess moisture should be avoided, especially in the first few days after emergence [9].

Plant height and number of leaves emitted

In Yamoussoukro, plant heights and numbers of leaves emitted varied between 48.36 cm and 54.13 cm and between 9.6 cm and 12.80 cm respectively (Table 4). In Ferkessédougou, plant heights ranged from 47.24 cm to 53.86 cm and the number of leaves produced fluctuated between 9.20 cm and 12.46 cm (Table 5). In each locality, the differences in height and number of leaves produced observed between plants showed a significant effect ($p<0.001$) of sowing dates ($p<0.001$). The values of each parameter decreased progressively from early to late planting. Similar results were obtained by George et al. who indicated that early seedings gave the highest values of the growth parameters [10]. In contrast, Mollah et al. reported that onion plants planted in November were longer and had more leaves than those planted in October [11]. This difference could be attributed to climatic variations between study sites.

Bulb rot rate at harvest

Bulb rot rates observed at harvest ranged from 0% to 6.04% at Yamoussoukro and from 0% to 5.50% at Ferkessédougou (Tables 4 and 5). The analysis of variance performed at the 5% threshold showed that sowing dates had a significant impact ($p<0.001$) on the rate of bulb rot at harvest. Bulb rot is most noticeable for early seedings and low to nil for late seedings. This is due to the fact that early seeded plants have completed their cycle before the end of the rainy season. The bulbs were exposed to moisture during ripening. Unlike the early seeded plants, the late seeded crops did not show rot because bulb maturation and harvesting took place in the early dry season (November-December).

Total yield

Yield was affected by the date of sowing. Thus, at Yamoussoukro, values ranged from 17.65 tha^{-1} to 23.56 tha^{-1} (Table 4). The best yields were obtained respectively for sowing dates D3 (23.56 tha^{-1}), D4 (22.42 tha^{-1}) and D2 (20.27 tha^{-1}).

At Ferkessédougou, yields varied between 14.30 tha^{-1} and 23.72 tha^{-1} (Table 5). The yields obtained for sowing dates D2 (23.72 tha^{-1}) and D3 (23.15 tha^{-1}) were statistically equal and higher for those of sowing dates D1 (19.58 tha^{-1}) and D4 (17.53 tha-1) and D5 (14.30 tha^{-1}). The best yields at these planting dates would be the result of plant survival rates after transplanting. Rizk and Nasir et al. observed that onion yield is positively correlated with planting density [12,13].

Average bulb weights

In Yamoussoukro, average bulb weights fluctuated between 69.32 g and 73.08 g (Table 4). The differences observed were significant ($p=0.002$) at the 5% threshold. The mean bulb weights obtained on sowing dates D1 (73.08 g) and D2 (72.95 g) were statistically equal and higher than those on dates D3 (71.89 g), D4 (71.14 g) and D5 (69.32 g). At Ferkessédougou, the values ranged from 70.36 g to 73.65 g (Table 5). Here again, the effect of sowing date was significant ($p=0.012$) on average bulb weight. Average bulb weights were higher for D1 (73.65 g), D2 (72.80 g) and D3 (72.62 g). In both Yamoussoukro and Ferkessédougou, average bulb weights decreased gradually from the first sowing date to the last date. This would be related to the reduction in height and number of leaves emitted from the plants. Studies by Guesh have shown that average bulb weight is positively correlated with plant height and number of leaves emitted [14].

Sowing dates	PSR (%)	PH (cm)	NL	BRR (%)	TBY (t/ha)	ABW (g)
D1	78.51^{e}	54.13^{a}	12.80^{a}	6.04^{a}	17.65^{d}	73.08^{a}
D2	88.23^{c}	52.75^{b}	11.06^{b}	4.29^{b}	20.27^{c}	72.95^{a}
D3	94.38^{a}	51.44^{b}	10.73^{bc}	2.67^{c}	23.56^{a}	71.89^{ab}

D4	92.86^{b}	49.07^{b}	10.06^{cd}	1.63^{d}	22.42^{a}	71.14^{ab}
D5	84.22^{d}	48.36^{c}	9.60^{d}	0.00^{d}	18.40^{d}	69.32^{b}
p-value	0.000	0.000	0.000	0.000	0.000	0.002
CV (%)	7.41	3.64	13.45	27.61	11.58	2.45

Note: PSR: Plant Survival Rate after transplanting; PH: Plant Height; NL: Number of Leaves emitted; TBY: Total Bulb Yield; ABW: Average Bulb Weight; BRR: Bulb Rotting Rate at harvest; CV: Coefficient of Variation.

The averages of each parameter assigned the same letter are statistically identical to the 5% threshold (Test of Newman-Keuls).

Table 4: Effects of sowing date on growth and production parameters of ares onions at Yamoussoukro.

Sowing dates	PSR (%)	PH (cm)	NL	BRR (%)	TBY (t/ha)	ABW (g)
D1	92.28^{a}	53.86^{a}	12.46^{a}	5.50^{a}	19.58^{b}	73.65^{a}
D2	91.1^{a}	51.44^{a}	11.20^{b}	3.46^{b}	23.72^{a}	72.80^{a}
D3	89.15^{a}	50.37^{b}	10.64^{b}	0.88^{c}	23.15^{a}	72.62^{a}
D4	78.51^{b}	49.21^{b}	9.53^{c}	0.00^{c}	17.53^{c}	71.26^{b}
D5	71.21^{c}	47.24^{c}	9.20^{c}	0.00^{c}	14.30^{d}	70.36^{b}
p-value	0.000	0.000	0.00	0.000	0.000	0.012
CV (%)	10.29	3.25	13.37	38.24	18.56	1.97

Note: PSR: Plant Survival Rate after transplanting; PH: Plant Height; NL: Number of Leaves emitted; TBY: Total Bulb Yield; ABW: Average Bulb Weight; BRR: Bulb Rotting Rate at harvest; CV: Coefficient of Variation.

The averages of each parameter assigned the same letter are statistically identical to the 5% threshold (Test of Newman-Keuls).

Table 5: Effect of sowing date on the growth and production parameters of Ares onion at Ferkessedougou.

Choice of the best sowing dates

Seeding dates were screened by study area using Principal Component Analysis (PCA) based on plant survival after transplanting, growth parameters and production parameters.

In Yamoussoukro, axes 1 and 2 contributed 98.69% to the observed variation. The parameters were highly correlated with axis 1 (67.95%). This axis made it possible to screen the best sowing dates which are D2, D3, and D4 (Figure 1).

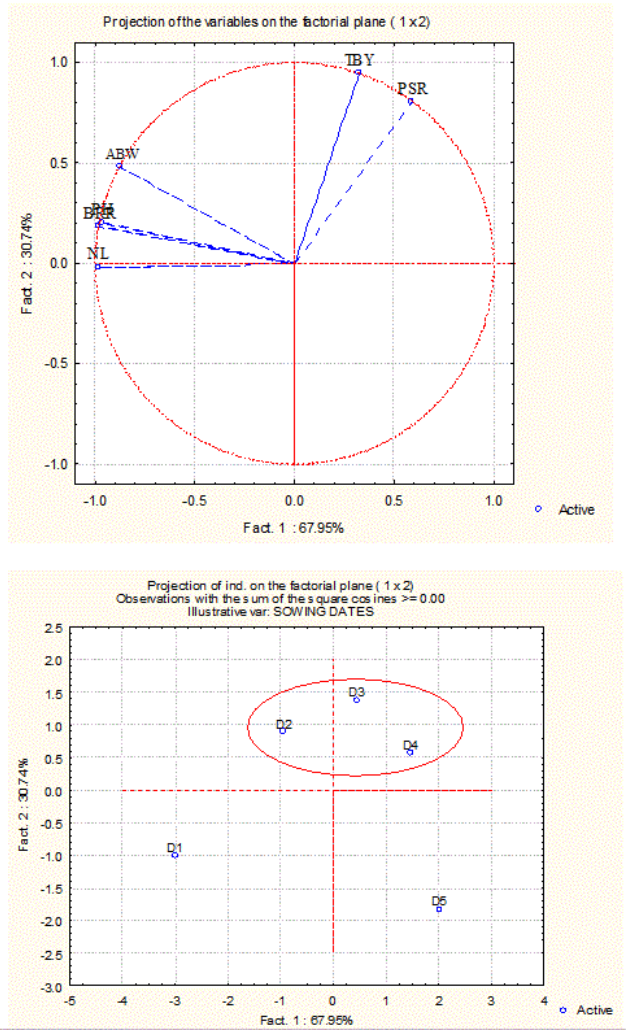

Figure 1: Circle of correlations (a) and scatter of sowing dates (b) obtained after PCA of growth and production data in the rainy season at Yamoussoukro.

At Ferkessédougou, the contribution of axes 1 and 2 to the observed variation was 98.04%. The parameters were strongly and negatively correlated with axis 1 (86.58%). The dispersion of sowing dates on the factorial level showed that the best sowing dates in this locality were D2 and D3 (Figure 2).

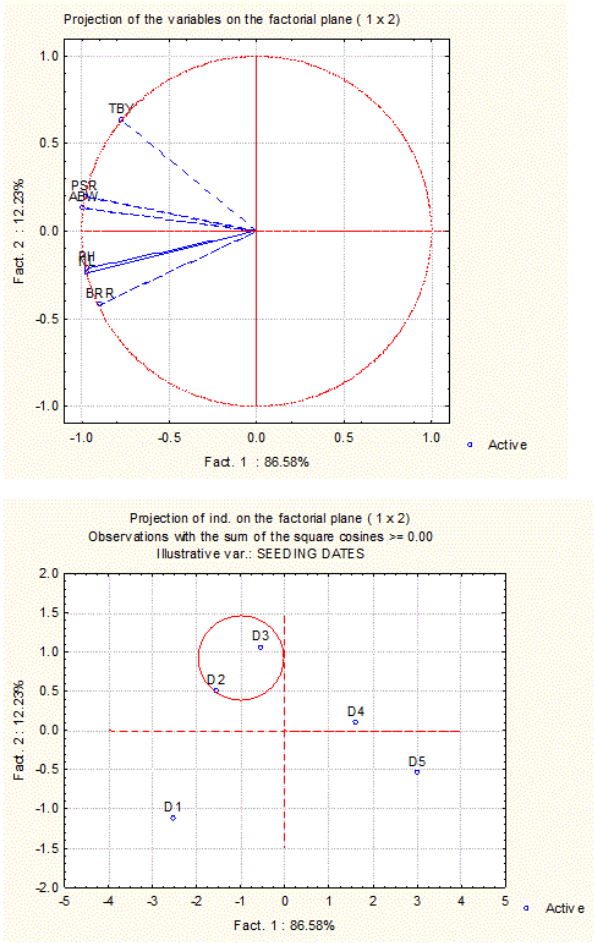

Figure 2: Circle of correlations (a) and scatter of sowing dates (b) obtained after PCA of growth and production data in the rainy season at Ferkessédougou.

Conclusion

The effects of the tested planting dates on growth and production parameters were evaluated at both locations. As a result, the best-performing planting dates were identified for each location using a principal component analysis. In Yamoussoukro, center of Ivory Coast, the best results were obtained for sowing dates D2, D3 and D4. On the other hand, in Ferkessédougou, in the north, the best results were obtained for sowing dates D2 and D3. Thus, for rainfed onion production in central Côte d'Ivoire, the nursery should be set up between 15 May and 15 June. In the north, the ideal period for setting up the nurseries is from 15 May to the first week of June.

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