Performance of Onion Seed Production Under Organic and Mineral Fertilizers in the Soudano-Sahelian Zone of Cameroon.

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The study on the improvement of the quantitative and qualitative production of onion seeds was carried out at the IRAD experimental site in Meskine. This trial was conducted using a completely randomized experimental block design with seven treatments (fertilizers) for six replicates. Thus, at 45 JARS, the application at a rate of 250 kg/ha and 15 t/ha broadcast respectively for mineral fertilizer (27-13-13; 14-23-14; 12-14-19; 22-10-15 and 46-0-0) and for goat manure (organic fertilizer). In addition, a biostimulant was applied at a dose of 1 l/ha using the sprayer (ULVA). The data collected was analyzed with IBM SPSS Statistics version 20 software at the 5% significance level. The analysis of the results obtained shows that formulations 27-13-13 (T1) and 12-14-19 (T3) shortened the number of days of appearance of the first bolting and flowering by two (2) days. The high yield and maximum weight of 1000 grains were obtained with the T0 treatment, which is goat manure. The treatment (T2) based on the 14-23-14 formulation of fertilizer made it possible to obtain a maximum rate of germination and its germination power. The correlation test between the parameters of early childhood of plants at different phonological stages has identified that the 22-10-15 (T+) formulation ensures the rapid development of different parts of the plants. The result of the correlation test between the studied development and yield parameters made it possible to identify the 14-23-14 (T2) formulation as the best fertilizer for onion seed production.

Keywords: Performance; Onions; Seeds; Formulation and Fertilization.

Introduction:

Agriculture remains the most important economic sector in Africa. It contributes to at least 40% of exports, 35% of GDP, and generates 60% of the jobs created [1]. It reduces poverty and promotes economic growth through its contribution to GDP, employment, and trade. It remains the main source of income for 65 to 70% of the African population [2]. But at the same time, increasing urbanization, reducing arable land have pushed market gardeners to move towards a so-called intensive cultivation system with a sometimes-abusive use of chemical inputs and, in particular, mineral fertilizers.

In Cameroon, as in several countries around the world, market gardening, and more specifically onion cultivation, is more than ever a sector of the future for many producers, as it is one of the income-generating activities by contributing to the overall economic growth of many households in rural areas [3]. Moreover, onions are a significant source of income [4]. Thus, the economic importance of onions in the regions where they are grown is undeniable.

It is ranked second among the most cultivated vegetables in the world after tomatoes [5]. Its global production is estimated at 4365.95 M/t [6]. Onion production has been growing significantly over the past twenty years in various countries in sub-Saharan Africa [7]. In 2017, the total onion production in Africa was 12.17 million tons [8], and five years later, it increased to 14,896,148.32 tons (FAOSTAT, 2022). The main onion-producing countries in Africa are Egypt, Algeria, Sudan, Nigeria, Niger, and Morocco (FAOSTAT, 2022). In the Central African sub-region in particular, annual onion production is about 90,000 tons with an average yield of 10 t/ha [8]. In Cameroon, the onion sector is an agricultural sector that brings together the various actors and accounts for most of the national production, with a production of 386,756.69 tons (FAO, 2022). Cameroon's onion production is 85% supplied by the North and Far North Regions [9]. In the northern part of the country, onions are ranked as the third cash crop after cotton and groundnuts, and are the leading market gardening crop [7]. In intensively cultivated farms in the Far North region, onions account for 45% of producers' net income [10].

Apart from its economic importance, the onion is cultivated for its medicinal and nutritional virtues. Medicinally, onion is used for the treatment of infections, respiratory inflammations, and rheumatism; their lipid-lowering properties are important for the prevention of diseases [11]. In terms of food, onions are rich in nutrients such as carbohydrates, proteins, lipids, mineral salts (Ca^{2+}, Mg^{2+}, K^{+}, Fe^{2+}), as well as multiple vitamins (C, B, E) [12]. Some of the leaves, before the bulb forms, are eaten raw, alone or in salads [12]

Despite its multitudes, onion production is less efficient due to certain production constraints [13]. These production constraints include: the poor use of production factors (land, labor, capital), the application of traditional cultivation practices, the loss of soil fertility due to its over exploitation by market gardeners, high purchase costs and above all the insufficiency of seeds at the local level leads to a dependence on imported seeds which do not respond well to local pedo-climatic conditions. However, expenses related to the purchase of seeds alone constitute 16% of the cost of production [14]. This forces producers to ensure their seed production. Thus, in the Far North of Cameroon, the availability of good-quality seed in sufficient quantity is a major concern for producers. However, the performance of onion seed production under different organic and mineral fertilizers has attracted little research in this agro-ecological zone. It is with this in mind that a study has been carried out to identify the best fertilizer that will improve the technical seed production itinerary of the onion (Allium Cepa) crop in the Far North region.

Objectives and Novelty Statement of this Study.

However, the performance of onion seed production under different organic and mineral fertilizers has not been tested in this agro-ecological zone. Therefore, this study will:

Evaluate onion growth parameters on the effects of organic and mineral fertilizers in the Far North region of Cameroon,

Evaluate seed yield and quality under the effects of organic and mineral fertilizers in the Far North region of Cameroon,

Determine the cost analysis of the production of onion seed under the different fertilizers applied.

However, it should be noted that this study aims to shed new light on the use of organic and mineral fertilizers for onion seed production in the region, highlighting the importance of promoting organic fertilizers that respect the environment. By comparing the performance of these different formulations, the study seeks to identify the most effective solutions to improve crop yields, seed, and producers' incomes while preserving the health of soils and the local ecosystem. The results of this research could help guide farmers towards more sustainable and profitable practices, while promoting more environmentally friendly agricultural production. It is with this research idea in mind that a study was conducted on mastering knowledge on the application and effective management of organic and mineral fertilizers to improve the technical itinerary of seed production of onion (Allium Cepa) in the Far North region.

Material and Methods:

Description of the Study Site:

The experiment was carried out at the application farm of the Agricultural Research Center for Development (CRA) in Maroua. This site is located in the Mangalaré district of Meskine, about 10 km from the center of the city of Maroua. Meskine is a canton bordered to the east by Makabaye, to the west by Katouwal, and to the north and south by the district of Gazawa. The geographical coordinates of this test site are 10°54.26 North and 14°25.04 East. It is located at an altitude of 414 m and covers an area of 10 ha.

Equipment and Fertilizers Used:

The plant material used is the Goudami variety of the onion (Allium Cepa). This variety was introduced from Worldveg in Mali. It has undergone the selection and purification process at the IRAD level to improve its performance (homogeneity and yield).

Fertilizers Used:

Several types of fertilizers were used for our experiment: mineral fertilizer, organic fertilizer, and biostimulant.

Mineral fertilizer:

Table 1 below shows the different mineral fertilizers used and their proportion of the major elements.

Table 1. Fertilizer formulations and nutrient proportions

Formulations	total nitrogen N	Phosphorus oxide (P_2O_5)	Potassium oxide (K_2O)
NPK 27-13-13	27%	13%	13%
NPK 14-23-14	14%	23%	14%
NPK 12-14-19	12%	14%	19%
NPK 22-10-15	22%	10%	15%
Urea 46-00-00	46%	00%	00%

Organic Fertilizer:

Organic Manure (Goat Manure):

Manure is the product of the fermentation of a mixture of more or less trampled straw and animal excrement, which allows an efficient recycling of mineral elements that are more concentrated and more absorbent than in the original residues. It can be used as an organic amendment, with positive effects on soil structure and raising the acidic pH [15]. According to [15], the NPK agronomic characteristics of goat manure are as follows: Fertilizer equivalence coefficients N: 0.2, P2O5: 1, K2O: 1. Fertilizer element composition of goat manure (kg/t of crude product).

Bio Stimulant:

The smartfoil produced by the company Agrauxine is a biostimulant based on metabolites from yeast fermentations. It is a biostimulant for foliar use whose role is to allow plants to limit the effect of abiotic stresses. Its role is to ensure the plant's resistance to abiotic stresses, plant growth and development, better nutrient absorption, and better crop quality.

Experimental Design:

The experimental design consists of completely randomized plot blocks with seven treatments and six replicates. Each replicate is made up of seven elementary plots corresponding to the seven treatments of the fertilizing factor (the different formulations). That is 42 elementary plots for the entire system. The dimensions of the elementary plots (lockers) are 2 m x 1.5 m, i.e., 03 m². The number of plants per elementary plot is 30, which means 1260 plants for the entire experimental setup. 0.5 m, and the elementary plots separate the blocks from each other by 50 cm. The total area of the trial is 126 m². The experimental design is presented in Figure 1 below.

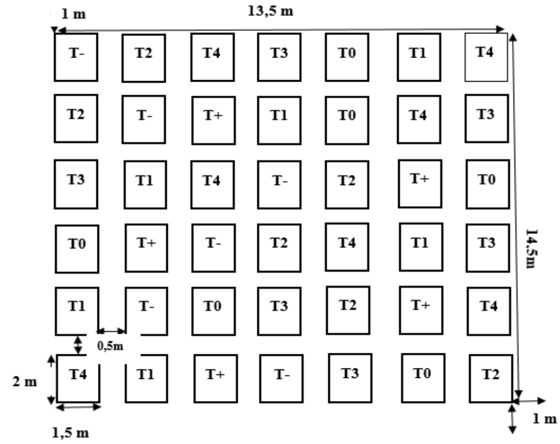

Figure 1. Diagram of the distribution of treatment on the experimental plot

Conduct and Installation of the Test:

To conduct the trial, an onion seedling nursery was built using onion bulbs from the previous year's crop; Animal traction is carried out beforehand for the preparation of the plot. The 2m*1.5m lockers are made using a string and a decimeter to measure the dimensions. Stakes were used to mark the corners of the plots. Before transplanting, the land was cleaned, moistened, ploughed, and harrowed.

Transplanting:

It was carried out 45 days after the nursery with a spacing of 25 cm between the plants and 40 cm between the rows.

Irrigation and Maintenance:

It was carried out according to a timetable established for this purpose. A frequency of irrigation of once a week using a motor pump is carried out. The maintenance consisted of weeding according to the state of grass cover of the plot.

Treatments Applied:

Table 2. The different treatments applied.

Codification of treatments	Types of fertilizers
T N	Urea 46 %
T+	Formulation 22-10-15
T_0	Caprin manure
T_1	Formulation 27-13-13
T_2	Formulation 14-23-14
T_3	Formulation 12-14-19
T_4	Biostimulant SMART

The treatments were applied 45 days after transplanting. It was carried out by spreading and at a dose of 250 kg/ha for mineral fertilizer (27-13-13; 14-23-14; 12-14-19; 22-10-15 and 46-0-0), 15t/ha for goat manure, and by spraying a biostimulant at a dose of 1L/ha.

Harvests:

They began on the 92nd day after transplanting (DAT) for a cycle of 130 to 140 days. The umbels are harvested with ± 5 to 10 cm and then dried in the shade. Threshing takes place when the umbels are well dried (about 15-20 days). The work is done as carefully as possible so as not to injure the seeds. The resulting grains are washed and dried before packaging for storage (Figure 2).

Figure 2. Stem drying (a) and grain drying (b).

Data Collection:

Morphological parameters:

As for morphological parameters, data concerning plant height, plant diameter, and flower spread are collected on a sample of five (05) plants per experimental unit.

Cultural Cycle Parameters

Duration of the Cultural Cycle:

The dates of appearance of the flower umbel are converted into the number of days after transplanting. They are determined by observations made every two days at the plot level for each experimental unit.

The flowering start dates which is converted into the number of days after transplanting. They are determined by observations made every two days at the plot level for each experimental unit (Figure 3a).

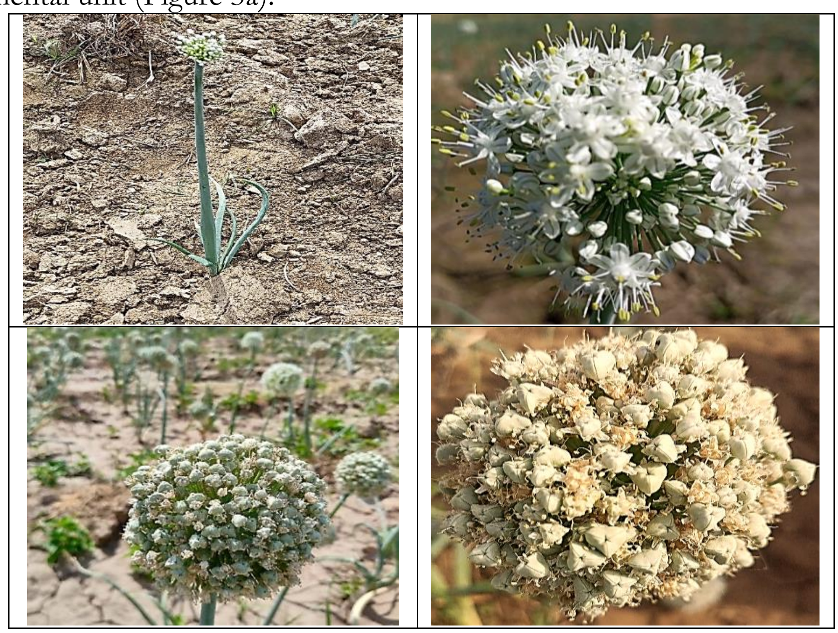

Figure 3. Different stages of observation of the different rates: (a) = floral buttons; (b) = flowering; (c) = fruit set; (d) = ripening fruit.

Rate of plants at different stages of development:

The recovery rate is the number of plants that have grown out of the total number of plants transplanted in the different experimental units. It is determined by counting the plants one week after transplanting.

% TR = (NbPR/NbTP) x 100 (1)

With: NbPR: number of plants recovered; NbTP: number of total transplanted plants.

The rate of plants that have produced one bolting, which is the number of plants that have one bolting out of the total number of plants included in the different experimental units (Figure 3a). They are determined by counting plants with at least one plant bolting.

% HP = (NbHP/NbPR) x 100(2)

With: NbHP: number of plants with a scape; NbPR: number of plants recaptured.

The rate of plants that have flowered: which is the number of plants that have flowered out of the number of plants with a stalk in the different experimental units (Figure 3b). They are determined by counting plants with at least one plant bolting.

% HF = (NbPF/NbHP) x 100 (3)

With: NbPF: number of flowering plants; NbHP: number of plants with a scape.

The rate of fruiting plants, which is the number of fruiting plants out of the number of plants that have flowered in the different experimental units (Figure 3c). They are determined by counting plants with at least one plant bolting.

% HFR = (NbPFr/NbPF) x 100 (4)

With: NbPFr: number of fruiting plants, NbPF: number of flowering plants;

The rate of plants with several stalks greater than two, which is the number of plants with more than two stems out of the total number of plants flowering in the different experimental units. Determine by counting the plants according to the number of bolting they carry.

% TM = (NbPHsd/NbPR) x 100 (5)

With: NbPHsd: the number of plants with more than two flower stalks; NbPR: number of plants recaptured.

Development Parameters:

The height of the bolting part was determined by measuring the stem carrying the flower stalk using a ruler.

The diameter of the swollen part of the flower stalk of plants is measured using a digital caliper.

The spread of the flowers, which corresponds to the diameter of the inflorescences, is measured using a measuring scale.

Yield Performance:

The grain yield per plant and unit area: this is obtained by weighing total grains on each experimental unit after threshing. The number of flowering plants in each unit is then divided by this mass.

The weight of 1000 seeds was measured using a 0.01g precision scale after manual grain counting for each experimental unit.

The weight of the bulbs obtained in each experimental unit is measured to assess the correlation between the bulb and seed yield.

The germination rate: for this reason, 20 grains per experimental unit, i.e., 120 seeds per treatment, are cultured at room temperature on a substrate soaked in water promoting germination, and then the germinated grains are counted each day. The number of grains germinated after a week corresponds to the germination rate.

Evaluation of Cost-Benefit Analysis:

For the evaluation of profits and charges related to production costs, the following elements will be taken into account in CFA francs: production operation (labor in man-day); seeds, rental of parcel, fertilizing elements; depreciation, other charges (packaging, guarding, transport). Profit assessment will be done by following the formula.

Profit (cfa f) = [yield (T/ha) * Pi] - total cost (cfa F) (6) ([16]).

Pi = selling price in kg cfa F for seeds onion

All inputs and outputs (seeds, onions) were assessed at market prices at the time of operations.

Data Processing:

For each variable studied (precocity; development and yields), the data collected were analyzed using the analysis of variance method (ANOVA), using the SPSS version 20 software. In addition, the Duncan test was used to assess the difference between the means of the treatments and the varieties on the different parameters studied at the 5% significance (PPDS). The bivariate test was used to determine the correlation coefficients of the different agronomic parameters. Moreover, the Microsoft Excel 19 spreadsheet was used for data entry and graphing.

Results:

Effect of Fertilizer Formulations on Agronomic Parameters:

The duration of the cycle and the rate of plants evaluate the effect of different fertilizers on the agronomic parameters of the seed plant at different stages of development.

Cycle Duration:

The average number of days after transplanting for early appearance of first bolting, first flower, and 50% flowering for different treatments is shown in Table 3.

Table 3. Effect of fertilizer formulations on early flower appearance

Treatments	NJAPH	NJAPF	D50%F
T+	25 ± 3.14	51 ± 2.14	61 ± 5.31
T_0	26 ± 2.34	53 ± 11.77	57 ± 4.14
T_1	23 ± 3.56	48 ± 3.31	57 ± 2.94
T_2	27 ± 1.52	51 ± 3.51	60 ± 4
T_3	27 ± 1.55	48 ± 5.60	59 ± 4.53
T_4	25 ± 3.37	49 ± 3.95	58 ± 1.16
TN	26 ± 2.79	49 ± 6.08	61 ± 6.53
Total	26 ± 2.79 FG = 1.327; df = 6; P > .05	50 ± 5.81 FG = 0.610; df = 6; P > .05	59 ± 4.29 F Global = .702; df = 6; P > .05
Significances	**NS**	**NS**	**NS**

Results are presented as a mean ± standard deviation (n = 7). NJAPH: number of days of appearance of the first bolting; NJAPF: number of days of appearance of the first flower; D 50% F: number of days at 50% flowering; NS: Not significant.

Analysis of variance for the mean number of days to first bolting after transplanting showed a non-significant difference (FG = 1.327; df = 6; p = 0.271) for the fertilizers applied. Duncan's test divided the value into two classes. The mean number of days to first flower stalk appearance after transplanting ranged from 23 days for T1 to 27 days for T2 and T3, with a mean value of 26 days. The addition of the 27-13-13 formulation resulted in the first stem emerging in a shorter number of days, whereas the T2 and T3 formulations delayed the emergence of the first flower stem. A higher nitrogen content in one formulation resulted in the appearance of the first flower stem in a shorter number of days. The results obtained may be due to an equivalence of the NPK content in our different fertilizer formulations used, or to the fact that the local variety Goudami is less demanding in mineral elements to promote bolting production.

Regarding the mean number of days to first flower after transplanting, the analysis of variance revealed a non-significant difference (FG = 0.610; df = 6; p = 0.721) depending on the treatments applied. The mean number of days to first flower after transplanting ranged from 48 days for T1 and T3 to 53 days for T0, with a mean of 50 days. These differences in means could be explained by the results of soil analyses, which revealed the presence of available phosphorus in the soil. On the other hand, the small difference observed between T1, T3, and T0 could be due to the addition of fertilizers rich in nitrogen and/or potassium in the T1 and T3 formulations, which shortened the flowering period of the plants by providing them with the three essential elements for their growth, the soil already containing a good amount of phosphorus. The fertilizer with the droppings of goat favored the physical and chemical properties of the soil. This allows the ground to reconstruct in fertilizing elements that are available for the plant.

The analysis of variance of the mean number of days to 50% flowering after transplanting under different treatments is non-significant (overall F = 0.702; df = 6; p = 0.650) for the fertilizers applied. The mean number of days to 50% flowering after transplanting ranges from 57 days for T0 and T1 to 61 days for T+ and TN, with a mean of 59 days. The goat manure treatment and the 27-13-13 formulation achieved 50% flowering in a shorter number of days, unlike the 22-10-15 and 46-00-00 formulations, which delayed the achievement of 50% flowering compared to the average number of days.

Table 4 is an interpretation of the difference in days compared to the average number of days to first bolting and first flower under different fertilizers. This table shows that formulation T1 shortened the date of first bolting by 2 days, and treatments T0, T2, T3, and TN delayed it by 1 day. The date of first flower appearance was shortened by 2 days with formulations T1 and T3. Formulation T0 delayed the date of first flower appearance by 3 days. Formulation T3 lengthened the time between first bolting and flowering, while treatments T4 and TN shortened this time.

Table 4. Difference in days compared to the average of the appearance of the first bolting and the first flower.

Treatments	First bolting	Flowering
T_+	-1	1
T_0	1	3
T_1	-2	-2
T_2	1	1
T_3	1	-2
T_4	0	-1
TN	1	-1

TN : Urea 46% ; T+ : formulation 22-10-15 ; T0 : goat manure ; T1 : formulation 27-13-13 ; T2 : formulation 14-23-14 ; T3 : formulation 12-14-19 ; T4 : SMART biostimulant.

Regarding earliness parameters, formulations T1 and T3 shortened the average development cycle by approximately two days compared to the average. Fertilization with formulation T0 delayed the start of flowering by three days.

Growth, Flowering, and Fruiting Rates:

The average number of plants harvested and the average rate of plants at different stages of the development cycle (flowering, fruiting, plants with multiple bolts) for the different fertilizers applied are presented in Table 5.

Table 5. Analysis of variances in phonological development parameters.

Treatments	TPF	TPAPDHF	THFr
TN	89,31 ± 6,38	61,50± 7,39 a b	85,14 ± 6,49 b c
T+	84,96 ± 15,99	68,16± 11,13a b	88,77 ± 8,83 c
T_0	83,78 ± 6,32	60,77± 13,19 a b	83,61 ± 12,25 a b c
T_1	91,54 ± 6,27	60,84± 11,70 a b	86,25 ± 9,14 b c
T_2	89,03 ± 12,31	58,17± 9,60 a	86,41 ± 9,54 b c
T_3	94,44 ± 4,86	61,20± 8,94 a b	75,46 ± 3,93 a b
T_4	87,37 ±8,74	74,12± 15,96 b	73,02 ± 12,46 a
Total	88,63 ± 9,40 F G = 0,098 ;ddl =6 ; P > 0,05	63,54± 11,79 F G = 0,672 ; ddl =6 ; P > 0,05	82,67 ± 10,33 F G = 2,459 ; ddl =6 ; P < 0,05
Significance	**NS**	**S**	**S**

TN : Urea 46% ; T+ : formulation 22-10-15 ; T0 : goat manure ; T1 : formulation 27-13-13 ; T2 : formulation 14-23-14 ; T3 : formulation 12-14-19 ; T4 : SMART biostimulant. TPF: plant rate that has flowered, TPAPDHF: rate of plants with more than two bolting; THFr: fruiting stem level; NS: Not significant. Results are presented as a mean ± standard deviation (n = 7).

Analysis of variance (ANOVA) for the mean number of plants for each treatment showed a non-significant difference (FG = 0.885; df = 6; p = 0.721) depending on the fertilizers applied. The mean number of plants sampled ranged from 21 plants for T3 to 25 plants for TN, with a mean of 24 plants. These variations may be related to environmental factors, as no treatment had yet been applied at the time of data collection. This variability may be attributed to uncontrolled factors such as water availability, climate, temperature, and soil mineralization in the experiments.

For the flowering rate of plants in different formulations, ANOVA revealed a non-significant difference (FG = 0.098; df = 6; p = 0.500) depending on the fertilizers applied. The flowering rate ranges from 83.78% for T0 to 94.44% for T3, with an average rate of 88.63%. Treatment T3 has the best flowering rates; this formulation contains a high proportion of the K element compared to N and P, unlike T0, based on goat manure, which has the lowest rate. These results may be related to the reserves of the bulbs used as seeds. This may be related to fertilization during bulb production in year 1. Analysis of variance of the mean rate of plants with more than two bolts for the fertilizers applied revealed a non-significant difference (FG = 0.672; df = 6; p = 0.496). The average rate of plants with more than two bolts ranged from 58.17% for T2 to 74.17% for T4, with an average of 63.54%. These results showed that the biostimulant treatment (T4) promoted the production of several bolts per plant. In contrast, the treatment with the 14-23-14 formulation (T2) resulted in fewer bolts per plant. This can be explained by the role of biostimulants not only in the plant's absorption mechanism of nutrients available in the soil, but also in strengthening its resistance to abiotic stresses. Figure 4 below illustrates the fruiting rate of the stems.

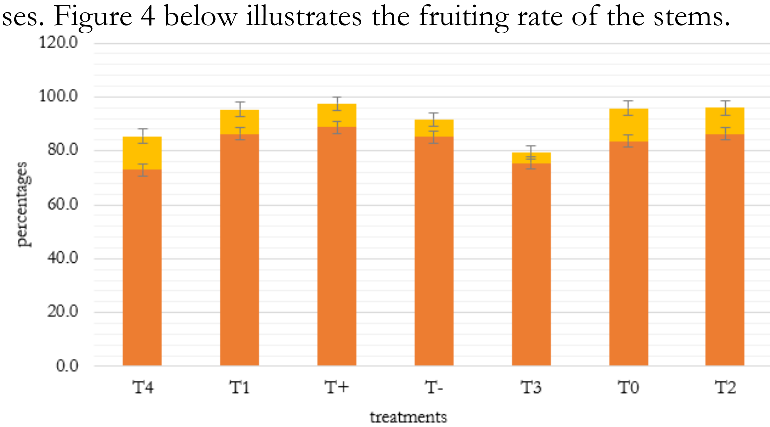

Figure 4. Average rate of stems to fruit.

For the average fruiting rate (Figure 3) under different treatments, the analysis of variance showed a significant difference (FG = 2.459; df = 6; p = 0.043). The average fruiting rate is between 73.02% for T4 and 88.67% for T+, with an average fruiting rate of 82.67%. The Duncan test divides these means into three classes. These results allowed us to affirm that the biostimulant, used in the production of seeds, does not promote the fruiting of the flowers produced. The treatment based on the 22-10-15 formulation (T+) ensured the fruiting of the flowers. This can be explained by the fact that the biostimulant promotes the rapid depletion of soil reserves of these nutrients for the plant. The addition of external nutrients made it possible to compensate for the deficit that the plant's nutrition can create during its development. The 22-10-15 (T+) formulation seems to be the balance to ensure good flower fruiting.

Variation in Height, Plant Diameter, and Inflorescence Spread:

Table 6 groups the average values of the seed holder development parameters (mean plant height, mean plant diameter, average inflorescence spread) for different treatments.

Table 6. Effect of fertilizer formulations on height, diameter, and inflorescence spreading.

Treatments	Average height of plants in cm	Average diameter of the plant in mm	Average spreading inflorescence in Cm
T+	48.06 ± 3.95	15.10 ± 1.91	5.97 ± .42
T0	50.29 ± 4.88	16.88 ± 1.28	6.41 ± .25
T1	50.38 ± 2.69	16.79 ± 0.66	6.39 ± .56
T2	48.07 ± 4.67	17.27 ± 1.18	6.67 ± .32
T3	46.95 ± 4.05	15.31 ± 1.06	6.15 ± .37
T4	50.46 ± 3.97	16.64 ± 1.58	6.21 ± .56
TN	49.47 ± 4.70	16.94 ± 1.83	6.14 ± .41
Total	49.10 ± 4.08 F G = .672 ; df = 6 ; P > .05	16.42 ± 1.53 F G = 2.171 ; df = 6 ; P > .05	6.28 ± .45 F G = 1.721; df = 6 ; P > .05
Significances	**NS**	**NS**	**NS**

TN : Urea 46% ; T+ : formulation 22-10-15 ; T0 : goat manure ; T1 : formulation 27-13-13 ; T2 : formulation 14-23-14 ; T3 : formulation 12-14-19 ; T4 : SMART biostimulant. NS: Not significant. Results are presented as a mean ± standard deviation (n = 7).

Analysis of variance of mean plant height for each fertilizer applied showed a non-significant difference (FG = 0.672; DDL = 6; p = 0.673). The mean plant height ranged from 46.95 cm for T3 and 50.46 cm for T4, with a mean height of 49.47 cm. The addition of 12-14-19 (T3) formulation to onion seed carriers hurt bolting height. The application of a biostimulant resulted in better seed carrier height. This explains the role of biostimulants, which is to improve growth capacity and protection against environmental stresses.

For the mean plant diameter under different treatments applied, the analysis of variance showed a non-significant difference (FG = 2.171; ddl = 6; p = 0.070). The mean plant diameter ranged from 15.10 mm for T3 to 17.27 mm for T2, with a mean of 16.42 mm. Although there was no significant difference, the minimum plant diameter was obtained with fertilizer T3, and the maximum diameter was obtained with formulation T2. A fertilizer whose formulation is richer in phosphorus than the elements nitrogen and potassium ensures the growth in width of the bolting.

Regarding the average inflorescence spread across the different formulations applied, analysis of variance revealed a non-significant difference (FG = 1.721; df = 6; p = 0.145) depending on the fertilizers applied. The average inflorescence spread ranged from 5.97 cm for T+ to 6.67 cm for T2, with a mean spread of 6.28 cm. Inflorescence spread was greatest with the higher phosphorus formulation, and with equal proportions of nitrogen and potassium. Phosphorus, therefore, promotes better inflorescence spread. Although the 22-10-15 (T+) formulation contains a higher nitrogen content, the proportion of potassium is higher than that of phosphorus. Therefore, there is an interaction between the proportion of phosphorus and potassium, the high content of which inhibits the function of nitrogen.

Yields Components:

Bulb Yield, Grain Yield, and Average Grain Weight:

The yield parameters (Average yield per plant in g; Average weight of 1000 grains in g; Bulb yield per hectare in Kg) for different treatments are grouped in Table 7.

Table 7. Bulb yield, grain yield, and average grain weight.

Treatments	Average yield per plant in g	Average weight of 1000 grains in g	Average weight of grains and onions in kg/ha	Bulb yield onion kg/ha
T+	1.01 ± .24	3.24 ± .24	70.7 ± 2.4	3997.22 ± 15.46
T0	1.37 ± .24	3.40 ± .29	95.9 ± 2.9	3611.11 ± 44.00
T1	1.16 ± .35	3.15 ± .14	81.2 ± 2.2	3108.33 ± 46.98
T2	1.20 ± .28	3.28 ± .36	84 ± 2.1	2927.78 ± 58.19
T3	1.11 ± .40	3.23 ± .26	77.7 ± 1,4	3175.00 ± 37.16
T4	1.22 ± .44	3.11 ± .31	85.4 ± 1.2	2986.11 ± 44.55
TN	1.12 ± .28	3.19 ± .20	78.4 ± 2.9	3350.00 ± 40.86
Total	1.17 ± .32 F G = .696 ; df = 6 ; P > .05	3.23 ± .26 F G = .759 ; df = 6 ; P > .05	135.23 ± 2.26 F G = .659 ; df = 6 ; P > .05	3307.94 ± 87.19 F G= 1.103 ; df = 6 ; P > .05
Significances	**NS**	**NS**	**NS**	**NS**

TN : Urea 46%N ; T+ : formulation 22-10-15 ; T0 : goat manure; T1: formulation 27-13-13; T2 : formulation 14-23-14; T3 : formulation 12-14-19; T4 : SMART biostimulant. NS: Not significant. Results are presented as a mean ± standard deviation (n = 7).

Analysis of variance of the average yield per cereal plant according to the fertilizers applied showed a non-significant difference (FG = 0.696; df = 6; p = 0.654). For the fertilizers applied, the average weight per plant in grains ranges from 1.01 g for T+ to 1.37 g for T0, with an average of 1.17 g. The low yield of the 22-10-15 (T+) formulation is related to the fact that this formulation does not allow good dispersion of the inflorescences. Adding fertilizer in a single dose did not allow the nitrogen in this formulation to cover the plant's needs to complete its cycle. On the other hand, the maximum yield is obtained with goat manure; this is due not only to its high potassium (K2O) content and its richness in organic matter, but also to the fact that the manure gradually releases the nitrogen (N) usable by the plant, allowing it to cover its cycle. For the average weight of 1,000 grains, the analysis of variance showed a non-significant difference for each fertilizer applied (FG = 0.759; df = 6; p = 0.607). The average weight of 1,000 grains is between 3.11 g for T4 and 3.40 g for T0, with a mean of 3.23 g. According to these results, the minimum weight of 1,000 grains is obtained with the biostimulant treatment.

Analysis of variance of bulb yield per hectare for each treatment showed a non-significant difference (FG = 1.103; df = 6; p = 0.380). Bulb yield per hectare ranged from 2927.78 kg for T2 and 3997.22 kg for T+, with an average yield of 3307.94 kg for the fertilizers applied. Maximum bulb production in the seed field was obtained under fertilization with the T+ formulation.

Effect of Formulations on Germination of Produced Seed:

Table 8 lists the qualitative parameters for different treatments.

Table 8. Seed germination rate.

Treatments	The average number of grains germinated at seven days	The average number of grains germinated at fourteen days	The number of grains germinated at twenty days	Average germination rate of seeds in %
T+	3.83 ± 1.32	6.67 ± 1.21	8.67 ± 1.21	43.33 ± 6.06
T0	4.83 ± 2.31	9.00 ± 1.90	11.17 ± 1.72	55.83 ± 8.61
T1	4.5 ± 2.88	7.83 ± 3.54	10.00 ± 3.41	50.00 ± 17.03
T2	4.33 ± 1.50	10.17 ± 4.02	12.33 ± 4.03	61.67 ± 20.17
T3	5.5 ± 2.42	9.67 ± 4.37	11.83 ± 4.45	59.17 ± 22.23
T4	6.5 ± 2.34	9.83 ± 3.49	12.17 ± 3.49	60.83 ± 17.44
TN	3 ± 2.19	9.00 ± 3.03	11.50 ± 2.81	57.50 ± 14.05
Total	4.64 ± 2.29 F G = 1.588; ddl = 6 ; P > .05	8.88 ± 3.22 F G = .868; ddl = 6 ; P > .05	11.10 ± 3.21 F G = 1.018; ddl = 6 ; P > .05	55.48 ± 16.07 F G = .241; ddl = 6 ; P > .05
Significances	**NS**	**NS**	**NS**	**NS**

TN : Urea 46% ; T+ : formulation 22-10-15 ; T0 : goat manure ; T1 : formulation 27-13-13 ; T2 : formulation 14-23-14 ; T3 : formulation 12-14-19 ; T4 : SMART biostimulant. NS: Not significant. Results are presented as a mean ± standard deviation (n = 7).

Analysis of variance of the mean number of germinated grains at seven days for each fertilizer applied showed a non-significant difference (FG = 1.588; df = 6; p = 0.178). The mean number of germinated grains at seven days is 3 grains for TN and 5.5 grains for T+, with a mean number of germinated grains of 4.64. The mean number of germinated grains at fourteen days for each fertilizer applied shows a non-significant difference (FG = 0.868; df = 6; p = 0.301) for the fertilizers applied. The mean number of germinated grains at fourteen days varies from 6.67 (T+) to 10.17 (T2) with a mean of 8.88. The number of germinated grains at twenty days for each fertilizer applied showed a non-significant difference (FG = 1.018; df = 6; p = 0.162). The number of germinated grains at twenty days ranged from 8.67 (T+) to 12.33 (T2, T4), with a mean of 11.10. At these three dates of evaluation of the number of germinated grains, the analysis of variance showed no significant difference. Under different treatments, a significant difference in means was observed at day 14. The highest mean was obtained with treatment T2 of formulation 14-23-14, and the lowest with treatment T+ of formulation 22-10-15. Analysis of variance of the mean seed germination rate in % for each fertilizer applied showed a non-significant difference (FG = 0.241; df = 6; p = 0.430) for the fertilizers applied. The mean seed germination rate in % ranged from 43.33% (T+) to 61.67% (T2) with a mean of 55.4%.

Correlation Between the Different Parameters:

Cultural Cycle:

Table 9 below shows the correlations between earliness parameters (first flower stalk, first flower, and fifty percent flowering).

Table 9. Correlation between precocity parameters.

	NJAPH	NJAPF	D50%F
NJAPH	1		
NJAPF	.429**	1	
D50%F	.562**	.497**	1

D50%F; .562**; .497**; 1

** The correlation is significant at the .01 level (bilateral test).

It appears from this table that there is a very highly significant correlation between the different parameters of precocity. The correlation coefficient is .429 between the number of days of appearance of the first bolting and the number of days of appearance of the first flower. This shows that the number of days of appearance of the first bolting and the number of days of appearance of the first flower evolve in the same direction; therefore, the shorter the number of days of appearance of the first bolting, the shorter the number of days of appearance of the first flower.

The correlation coefficient is .562 between the number of days of appearance of the first bolting and the number of days of 50% flowering. This also shows that the number of days of appearance of the first bolting and the number of days of 50% flowering also evolve in the same direction, so the shorter the number of days of appearance of the first bolting, the shorter the number of days of 50% flowering is. These correlations show that the 27-13-13 (T1) formulation resulted in the first bolting and 50% flowering at a shorter number of days.

Heights, Diameters of Plants and Spread of Inflorescence:

The Pearson correlation test was conducted between some agronomic parameters shown in Table 10.

Table 10. Correlation of plant heights, diameters, and inflorescence spread.

	Plant diameter in mm	Spreading of the inflorescence in cm	Yield by plot in g
Plant diameter in mm	1		
Spreading of the inflorescence in cm	.358*	1	
Yield by plot in g	.177NS	.386*	1

* The correlation is significant at the .05 level (bilateral). NS = not significant

It appears from this correlation test that the seed yield per unit area is closely linked to the spread of the inflorescence with a coefficient of .386*, which is significant at the 5% threshold. At this threshold, there is a significant correlation between the diameters of the plant in mm and the spread of the inflorescence in cm, the coefficient of which is 0.358*. These correlations are positive. They show that the larger the diameter of the plant, the greater the spread of the inflorescence, and the higher the yield. The T0, T1, and T4 formulations with an element N content are the ones that would improve the yield because they ensure a good enlargement of the plant diameter, the greatest height, and a good spread of the inflorescence.

Yields Performance:

Table 11 below presents the correlation coefficients between the components' yield parameters at 5% for the bivariate Pearson Test.

Table 11. Correlation between components yield parameters.

	Yield in hectare bulbs in Kg	Yield by plant in g	Yield in hectare in g
Yield in hectare bulbs in Kg	1		
Yield by plant in g	-.103	1	
Yield in hectares per g	-.085	.714**	1

Pearson correlation test showed that there is a non-significant negative correlation between bulb yield per hectare in kg and grain yield per hectare in g. This result allows us to state that the 22-10-15 T+ formulation provides high bulb yield with low onion grain yield. The 14-23-14 (T2) formulation produces fewer bulbs and provides good grain yield.

Correlations of Seed Germination Rates at Three Dates:

The results of the Pearson correlation test between the qualitative parameters (seven-day germination rate, fourteen-day germination rate, and twenty-day germination rate) are grouped in Table 12.

Table 12. Correlation between seed germination rates at three dates

	Germination rate for seven days	Germination rate for fourteen days	Germination rate for twenty days
Germination rate for seven days	1		
Germination rate for fourteen days	.548**	1	
Germination rate for twenty days	.537**	.992**	1

** The correlation is significant at the .01 level (bilateral).

A highly significant correlation was observed between the germination rate at fourteen days and the germination rate at twenty days, with a coefficient of .992. This result can be seen as the number of days needed to assess the germination rate is 14 days after it is cultured. The high-performance formulation is 14-24-14 (T2), and it is the one that has resulted in more sprouted grains at 14 days. These positive correlations allow us to say that: the greater the number of grains that germinate at 14 days, the higher the germination rate.

Correlation Between Development and Yield Parameters:

Table 13 below shows the results of the Pearson correlation test between the development and yield parameters.

Table 13. Correlation between development parameters and yield

	DP in mm	**EI in Cm**	**HP in Cm**	**RG in g**	**RB in Kg**
DP in mm	1				
EI in Cm	.358*	1			
HP in Cm	.343*	.367*	1		
RG in g	.177	.386*	.037	1	
RB in Kg	-.057	-.072	.063	-.085	1

* The correlation is significant at the .05 level (bilateral test).

DP: Plant diameters, EI: Inflorescence spreading, HP: Plant height, RG: Grain yield, and RB: Bulb yield

The study of this table showed that the correlation coefficient between the grain yield and the spread of the inflorescence in cm is .386 and significant at the 5% threshold. This correlation is positive; it shows that the greater the spread of the inflorescence, the higher the grain yield. The formulation suitable for production would be the T2 treatment (14-23-14), as it achieved the greatest spread of the inflorescence.

Economic Analysis of Production of Onion Seeds:

Table 14 shows the profit from the income and the cost of production of onion seeds.

Table 14. Cost-benefit analysis of the production of seed onion

Treatments	Average yield in kg/ha	Revenue per Treatment	total cost of production in CFA F	Profits in CFA F
T+	70.7	4 949 000	1 701 782.88	3 247 217.12
T0	95.9	6 713 000	1 715 782.88	4 997 217.12
T1	81.2	5 684 000	1 717 782.88	3 966 217.12
T2	84	5 880 000	1 697 782.88	4 182 217.12
T3	77.7	5 439 000	1 709 782.88	3 729 217.12
T4	85.4	5 978 000	1 613 782.88	4 364 217.12
TN	78.4	5 488 000	1 664 782.88	3 823 217.12

TN : Urea 46% ; T+ : formulation 22-10-15 ; T0 : goat manure; T1: formulation 27-13-13; T2: formulation 14-23-14; T3: formulation 12-14-19; T4: SMART biostimulant.

It emerges from this table that the T0: goat manure, T2: formulation 14-23-14, and T4: SMART biostimulant have obtained significant gross margins of the order of 4,997,217.12, 4,182,217.12, and 4,364,217.12 CFA Francs, respectively. The greatest value in profit of T0 treatment is due to the low cost of organic fertilizer (goat manure), but only the cost of transport would have increased the cost of producing seed onion. The availability of goat droppings along the Mayo (red bridge) means that this fertilizer is free to bring for fertilization.

Discussion:

Effect of Fertilizer Formulations on Agronomic Parameters:

The result of the analysis of variance has shown that they are no significance between the agronomic parameters measured, such as number of days after transplanting for early appearance of first bolting, first flower, and 50% flowering. This result is not consistent with the work of [17], who showed that the physiological and agronomic role of nitrogen is to promote the vegetative development of the plant, delay flowering, and prolong the duration of the vegetative phase. The same results were obtained by [18], who emphasize that a nitrogen-rich formulation promotes leaf and stem growth, thus improving plant color and size, while potassium plays a critical role in maintaining cellular organization by regulating cell membrane permeability and maintaining protoplasm at an appropriate level of hydration by stabilizing emulsions with highly colloidal properties. The results of [19] showed that it is the phosphorus element that particularly promotes the establishment of strong root systems, improves rapid flower formation, and rapid plant growth. Particularly, the insufficient levels of phosphorus can lead to stunted growth, poor floral development, and reduced seed production. While in Ethiopia, bolting percentage was highly significantly ($P < 0.01$) influenced by the main effect of nitrogen, as increasing nitrogen from 0 to 150 kg N/ha decreased bolting percentage by 62% [20]. This may also be related to the plant's response to photoperiodism, which stimulates flowering. These results contrast with the work of [21] on the agronomic experiment of fertilizing the onion "*Allium Cepa*" with guanobarren in the case of Anevoka, which stipulates that the inflorescence of the onion is linked to the role of phosphorus on its physiology. Indeed, phosphorus promotes emissions linked to bolting. Increasing the dose of guanobarren only increases the flowering rate of the onions. The same idea is supported by [22], who reported that nitrogen fertilization significantly reduced bolting in onion, where the proportion of bolts per plot decreased by approximately 11% and 22% in response to nitrogen application at 69 and 92 kg N/ha.

Thus, in cycle production, the study by [20] in Ethiopia shows that flowering maturity (133 days) was extended thanks to the increased nitrogen application rate (150 kg N/ha). In addition, concerning yields in bulbs during the cycle of seed production, these results could be due to the homogeneous fertilization of the bulbs for seed produced the previous year, which ensured nutrient accumulation for the seed-bearing plant. They could also be due to the plant's photoperiodism. These results are consistent with [23] work on the interaction law in fertilization, according to which "the insufficiency of one available element in the soil reduces the effectiveness of other elements and, consequently, decreases yield."

However, at the height, diameter, and spreading of the inflorescence of plants, the analysis of variance has shown that there is no significant difference under the effect of the application of fertilizer. These results are in contradiction with the work of [24], who showed a higher increase in stem height between 76 and 93 cm for different onion cultivars. This increase in height with N application may be partly because nitrogen primarily contributes to the higher rates of vegetative growth and stem elongation when high doses of nitrogen fertilizer are applied to plants.

Frequently, this variability during the development cycle can be explained by the composition of the nutrients present in the different formulations used, on the one hand. This can also be attributed to the interaction between phosphorus and potassium, and the role of potassium in ensuring the strength and resistance of plants, on the other hand. These results are consistent with the work of [25], who showed that a phosphorus-rich formulation promotes the establishment of strong root systems, improves rapid flower formation, and promotes rapid plant growth. It can be attributed to environmental or uncontrolled factors such as water availability, climate, temperature, and soil mineralization., In fact, concerning the yield component of the production seed, the biostimulant does not provide nutrients to the plant, but activates the natural process of assimilation of nutrients available in the soil by accelerating their assimilation. The maximum weight is obtained with fertilizer T0, which is goat manure. This performance is linked to the fact that manure is richer in potassium, which promotes plant root activity and ensures grain maturation thanks to the mechanism of transport of substances from seed reserves, the gradual return of nitrogen to plants throughout the cycle, and the presence of trace elements (Mg, Zn, etc.) in its composition. In addition, the work of [26] contradicts these results by showing that the insufficient level of the element P would contribute to poor grain development.

This formulation has a higher proportion of nitrogen and potassium; the interaction between these two elements favors bulb formation and enlargement. In Ethiopia, the same studies showed that increasing the N rate from 0 to 100 kg N/ha significantly increased total bulb yield by 79.4% [20]. In the same line, a study demonstrated that in Ethiopia, significantly higher marketable bulb yield (41 t/ha) and total bulb yield (41.33 t/ha) were recorded from 300 kg/ha NPSB blended fertilizer applied rate [27]. Under 14-23-14 (T2) formulation, we obtained low bulb yield. On the other hand, the work of [28] shows that the highest application of phosphorus fertilizer has a major effect on the productivity of onion plants, thus increasing the total yield of bulbs and their components. Phosphorus application significantly increases and influences bulb length and diameter, average bulb weight, dry matter content of bulbs, marketable yield, and total bulb yield. In onions, phosphorus deficiency reduces root and leaf growth, bulb size, and yield [29]. The same result was obtained by [18], that the P deficiencies reduce root and leaf growth, bulb size, and yield, and can delay maturation. This result contradicts the physiological and agronomic role of nitrogen, according to which a high intake would promote vegetative development and delay the number of days of appearance of the first bolting, appearance of the first flower, and 50% of flowering [17]. Moreover, the days to 90% maturity of onion were affected by the main factors of NPSB fertilizer rate, variety, and planting pattern [27]. [30] shows that nitrogen is the main constituent of proteins, and its abundant presence tends to increase the size and diameter of onion leaves. On the other hand, the Phosphorus releases good germination energy to the grains and promotes good germination [26]. This result is not in agreement with the work of [28], who showed that the highest application of phosphorus fertilizer has a major effect on the productivity of onion plants, thus increasing the total yield of bulbs and their components. But the clay-sand soil (Mayo-kalio) presented at a dose of 700 kg/ha of NPK effectively yields the highest potential yield in t/ha is 74.02 t/ha with 12-14-19-3.5MgO-0.15B [31].

However, a negative and non-significant correlation is observed between grain yield and bulb yield (-.085 is non-significant); this is because an increase in bulb yield decreases grain yield. This result corroborates the work of [19], who shows that plants always tend to allocate their energy to seed formation to ensure their reproduction. Thus, grain yield increases with the high phosphorus content of the 14-23-14 (T2) formulation.

Economic Analysis of Production of Onion Seeds:

Comparatively, in the production of seed onions, the best optimal profit onion bulb in Cameroon is of the order of 283,471,445 CFA francs by 12-14-19-3.5MgO-0.15B formulation [31]. The net benefit of 232,486.00 ha was obtained from the treatment receiving 138 kg N/ha planted at an intra-row spacing of 7.5 cm in South-Eastern Ethiopia [32]. The economic analysis done by [33] in India revealed that the NHRDF Red 3 variety onion recorded net returns of 921,115.70 CFA Francs/ha. Otherwise, in Ethiopia, the highest net benefit of production bulb is 5,319,836.99 CFA francs with a higher cost (704,508.60 CFA francs), by application of 300 kg NPSB per ha is recommended [27]. In the same line, [34] reported that the highest net return (1,878,293.85 CFA francs per ha) was obtained in response to application of 191 kg per ha NPSB + 125 kg per ha Urea. While in the irrigation scheme, the highest net profit is 429,569 in the Eastern Amhara region, Ethiopia [35]. This variability in profit is observed, which is due to the characteristics of the experiment on the one hand. On the other hand, the prices of inputs and prices that vary from one environment to another and from one period and another. These results show that the activity of the production of onion seeds is more beneficial than the production of onion bulbs. Furthermore, there is a specificity in fertilizer formulation concerning the targeted objectives of the production.

Conclusion:

At the end of this study carried out at the Agricultural Research Center for Development of Maroua (CRA-Maroua), the question was to study the production performance of seeds under different organic fertilizers and minerals. These performances are evaluated on the development cycle of the crop and the grain yield of the seeds produced. Two components are taken into account for the evaluation of the effect of the different performing formulations on the grain holder cycle: the length of the crop cycle and the plant rates at each phenological level. The formulations 27-13-13 (T1) and 12-14-19 (T3) showed a better performance on grain holder earliness because they shortened the cycle by 2 days; on the other hand, goat manure (T0) delayed the cycle by 3 days compared to the average number of days. The evaluation of plant rates at each stage of development has identified that the 22-10-15 (T+) formulation is better suited to ensure better monitoring of the grain holder cycle. The performance assessment was based on both quantitative and qualitative bases. In quantitative terms, the best yield is obtained thanks to the T0 treatment, which is goat manure. This same fertilizer made it possible to give a maximum weight of 1000 grains. Seed quality is evaluated in two aspects: germination rate and germination energy of the grains. A maximum germination rate is achieved with the formulation 14-23-14 (T2) against. Treatment with this formulation resulted in 14 days of germinative energy. The correlation test between the different parameters of development and yields reveals that a positive and significant correlation is observed between grain yield, inflorescence spread, plant diameter, and plant height. But a negative correlation is observed between grain and bulb yield. The best formulation is 14-23-14 (T2) because it has the best profit (4,182,217.12 Cfa F).

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References:
[1] FAOSTAT, "Food and Agriculture data," *FAOSTAT*, 2018.
[2] E. M. Dembélé, "Africa's resources and exploitation strategies," *Pensee*, 2015, [Online]. Available: https://shs.cairn.info/revue-la-pensee-2015-1-page-29
[3] K. B. S. A. B. Rameez, U. B. Sana, "Economic analysis of onion (Allium cepa L.) production and marketing in district awaran," *J. Econ. Sustain. Dev.*, vol. 5, no. 24, pp. 2222–2855, 2014, [Online]. Available: https://www.researchgate.net/publication/270902805_Economic_Analysis_of_Onion_Allium_cepa_L_Production_and_Marketing_in_District_Awaran_Balochistan
[4] FAOSTAT, "Food and agriculture data," *Food Agric. Organ. United Nations*, 2015, [Online]. Available: https://www.fao.org/faostat/en/#home
[5] J. P. B. R. Abdou, Y. Bakasso, T. Adam, M. Saadou, "Oignon (Allium cepa L) : Biologie, système de culture et marqueurs génétiques pour l'analyse de la diversité en Afrique," *Thèse, Univ. Liège-Gembloux, Gembloux*, pp. 1–151, 2014.
[6] FAOSTAT, "Food and agriculture data," 2024, [Online]. Available: http://faostat.fao.org
[7] N. W. Magalie Cathala, "Onion, a booming production in Sahel-Sudanese Africa: the case of Northern Cameroon," *Cah. Agric.*, vol. 12, no. 4, 2003, [Online]. Available: https://revues.cirad.fr/index.php/cahiers-agricultures/article/view/30399#:~:text=Au Nord-Cameroun%2C l',hectares par 13 600 producteurs.
[8] FAOSTAT, "Food and agriculture data," 2017, doi: https://www.fao.org/faostat/en/#home.
[9] J. C. B. and V. A.-S. Regine Tchientche Kamga, Isaac Roger Tchouamo, Ronal Chendjou, "Gender inequality in smallholder onion (allium cepa l.) production in the far north region of Cameroon," *J. Gender, Agric. Food Secur.*, vol. 1, no. 3, pp. 85–103, 2016, [Online]. Available: https://agrigender.org/views/gender-inequality-in-cameron-JGAFS-132016-5.php
[10] C. S. Mangwa, "Analyse d'une organisation hybride par l'approche de Thomas et Hardy : le cas de la mise en place d'une Activité Génératrice de Revenus dans une ONG de développement en République Démocratique du Congo," *Rech. en Commun.*, vol. 47, no. 3, 2018, [Online]. Available: https://ojs.uclouvain.be/index.php/rec/article/view/45593
[11] D. George, P. U. Maheswari, and K. M. M. S. Begum, "Synergic formulation of onion peel quercetin loaded chitosan-cellulose hydrogel with green zinc oxide nanoparticles towards controlled release, biocompatibility, antimicrobial and anticancer activity," *Int. J. Biol. Macromol.*, vol. 132, pp. 784–794, Jul. 2019, doi: 10.1016/J.IJBIOMAC.2019.04.008,.
[12] C. P. Madina Konate, "Evaluation des potentialités nutritives et l'aptitude à la conservation de onze variétés d'oignon (*Allium cepa* L.) bulbe introduites au Burkina Faso," *Int. J. Biol. Chem. Sci.*, vol. 11, no. 5, pp. 2005–2015, 2018, doi: https://dx.doi.org/10.4314/ijbcs.v11i5.6].
[13] D. P. Sakatai, W. F. Alain, Y. Oumarou, N. Lazare, O. B. J. Paul, and A. B. Armand, "Optimal Evaluation of the Production of Five Main Varieties of Onion (*Allium Cepa*. L) Under Different Organo-Mineral Fertilizers in Cameroon," *Int. J. Agric. Econ. 2022, Vol. 7, Page 150*, vol. 7, no. 4, pp. 150–162, Jul. 2022, doi:

10.11648/J.IJAE.20220704.12.
[14] AFSA, "Les communautés de base produisent des semences d'oignon certifiées au Cameroun," *World Veg. Cent. Cameroon*, pp. 1–4, 2019.
[15] CIRAD-GRET, "Memento de l'agronome, Ministeres desaffaires étrangeres," *éditions QUÆ*, 2002.
[16] S. P. Derik, "Caractérisation de cinq variétés d'oignons (Allium cepa. L) à partir des paramètres physiques de la maturation des bulbes en vue d'optimiser leur production à l'Extrême-Nord Cameroun," *Afrique Sci. Rev. Int. des Sci. Technol.*, pp. 314–331, 2021, [Online]. Available: https://www.researchgate.net/publication/349518139_Caracterisation_de_cinq_varietes_d'oignons_Allium_cepa_L_a_partir_des_parametres_physiques_de_la_maturation_des_bulbes_en_vue_d'optimiser_leur_production_a_l'Extreme-Nord_Cameroun
[17] M. A. Shege Getu Yayeh, "Economic and agronomic optimum rates of NPS fertilizer for irrigated garlic (Allium sativum L) production in the highlands of Ethiopia," *Cogent Food Agric.*, vol. 3, no. 1, 2017, doi: https://doi.org/10.1080/23311932.2017.1333666.
[18] J. T. IMRANI, Nawal, Mohamed Chliyeh, "Effet de la fertilisation par différents niveaux de N P K sur le développement des maladies foliaires du riz," *J. Anim. Plant Sci.*, vol. 3, no. 1, pp. 3601–3625, 2014, [Online]. Available: https://www.researchgate.net/publication/293332710_Effet_de_la_fertilisation_par_differents_niveaux_de_N_P_K_sur_le_developpement_des_maladies_foliaires_du_riz
[19] J. Žinete, "The role of NPK fertilizers in modern agriculture: Fuelling crop growth and maximizing yields," *Int. J. Manures Fertil.*, vol. 11, no. 2, 2023, [Online]. Available: https://www.internationalscholarsjournals.com/articles/the-role-of-npk-fertilizers-in-modern-agriculture-fuelling-crop-growth-and-maximizing-yields.pdf
[20] G. K. and D. N, "Agronomic and Economic Evaluation of Nitrogen Fertilizer Rates and Intra Row Spacing on Growth and Bulb Yield of Onion (Allium cepa L.) under Rainfall Condition," *J. Biol. Agric. Healthc.*, vol. 6, no. 21, 2016, [Online]. Available: https://www.researchgate.net/publication/316047184_Agronomic_and_Economic_Evaluation_of_Nitrogen_Fertilizer_Rates_and_Intra_Row_Spacing_on_Growth_and_Bulb_Yield_of_Onion_Allium_cepa_L_under_Rainfall_Condition
[21] M. Mbaye, A. Ba, M. A. Toure, E. Faye, and M. Diop, "EFFECTS OF DIFFERENT LEVELS OF ORGANIC AMENDMENT AND MINERAL FERTILIZATION ON ONION (ALLIUM CEPA L.) AGRO MORPHOLOGICAL PERFORMANCES AND QUALITY IN SENEGAL RIVER VALLEY CONDITIONS," *J. Appl. Biol. Sci.*, vol. 18, no. 1, p. 2, 2024, [Online]. Available: https://www.jabsonline.org/index.php/jabs/article/view/1231
[22] L. . Y. Abdissa, T. Tekalign, "Pant, Growth, bulb yield and quality of Onion (Allium cepa L.) as influenced by nitrogen and phosphorus fertilization on vertisol I growth attributes biomass production and bulb yield," *African J. Agric. Res.*, vol. 6, no. 14, pp. 3252–3258, 2011, [Online]. Available: http://www.academicjournals.org/AJAR
[23] J.-F. Perrault, "Traité d'agriculture," *Antigonos Verlag*, 2024, [Online]. Available: https://books.google.com.pk/books/about/Traité_d_agriculture.html?id=WXTb0AEACAAJ&redir_esc=y
[24] A. S. Sidhu, J. S. Kanwar, and M. L. Chadha, "Seed production potential of different genotypes of onion," *ONION Newsl. Trop.*, 1996, Accessed: Aug. 14, 2025. [Online]. Available: https://worldveg.tind.io/record/24998
[25] J. Žinete, "The role of NPK fertilizers in modern agriculture: Fuelling crop growth and maximizing yields," *Int. J. Manures Fertil.*, vol. 11, no. 2, p. 001, 2023, [Online]. Available: https://www.internationalscholarsjournals.com/articles/the-role-of-npk-

fertilizers-in-modern-agriculture-fuelling-crop-growth-and-maximizing-yields.pdf
[26] N. G. & J. N. Galloway, "An Earth-system perspective of the global nitrogen cycle," *Nature*, vol. 451, pp. 293–296, 2008, doi: https://doi.org/10.1038/nature06592.
[27] A. and Diriba-Shiferaw, "Growth, Yield and Economic Advantage of Onion (Allium cepa L.) Varieties in Response to NPSB Fertilizer and Planting Pattern," *Int. J. Hortic. Agric. Food Sci.*, vol. 8, no. 1, 2024, [Online]. Available: https://aipublications.com/uploads/issue_files/1IJHAF-JAN20241-Growth.pdf
[28] A. R. and S. M. S. Shaheen, A.M., Fatma, "Growing Onion Plants Without Chemical Fertilization," *Res. J. Agric. Biol. Sci.*, vol. 3, no. 2, pp. 95–104, 2007, [Online]. Available: https://www.aensiweb.net/AENSIWEB/rjabs/rjabs/2007/95-104.pdf
[29] N. B. Yalew Teshome, "Review on the effects of phosphorus on growth and yield of onion (Allium cepa L.)," *Int. J. Agric. Nutr.*, vol. 4, no. 1, pp. 6–11, 2022, doi: 10.33545/26646064.2022.v4.i1a.46.
[30] A. T. Negasi Tekeste, Nigussie Dechassa, Kebede Woldetsadik, Lemma Dessalegne, "Influence of Nitrogen and Phosphorus Application on Bulb Yield and Yield Components of Onion (Allium Cepa L.)," *Open Agric. J.*, vol. 12, pp. 194–206, 2018, doi: https://doi.org/10.2174/1874331501812010194.
[31] A. B. A. Dérik P. Sakatai, Wassouo F. Alain, Lazare Ndouvahad, Olina B.J. Paul, "Optimization of the production of five (05) onion varieties tested at different doses of organic and mineral fertilizers in the Far North Cameroon.," *Int. J. Agric. Ext.*, vol. 11, no. 2, p. 8, 2023, [Online]. Available: https://www.esciencepress.net/journals/index.php/IJAE/article/view/4685
[32] W. S. Gessesew, K. Woldetsadik, and W. Mohammed, "Effect of nitrogen fertilizer rates and intra-row spacing on yield and yield components of onion (Allium cepa L. Var. cepa) under irrigation in Gode, South-Eastern Ethiopia," *Int. J. Plant Breed. Crop Sci.*, vol. 2, no. 2, pp. 46–54, 2015, [Online]. Available: https://catalog.ihsn.org/citations/49625
[33] A. K. C. Dikshit, Archana, N. K. Pandey, D. Tiwari, "Evaluation of Onion (Allium Cepa L.) Varieties for its Suitability in Bundelkhand Region," *J Krishi Vigyan*, vol. 9, no. 1, pp. 73–76, 2020, doi: 10.5958/2349-4433.2020.00148.8.
[34] A. T. G. Tesema, M. Malla, "Evaluation of blended fertilizer type on improving the productivity of onion (Allium cepa L.) in Bena Tsemay district, Southwestern Ethiopia," *J. Innov. Agric.*, vol. 8, no. 4, pp. 36–42, 2021, doi: 10.37446/jinagri/rsa/8.4.2021.36-42.
[35] B. M. A. Merawie, M. Alemayehu, "Optimal rate of nitrogen and intra-row spacing for economical production of onion under irrigated farming system in Eastern Amhara region, Ethiopia," *Curr. Res. Agric. Sci.*, vol. 6, no. 2, pp. 83–94, 2019, doi: 10.18488/journal.68.2019.62.83.94.