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Research Article

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

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ABSTRACT. The management of agricultural production became restrictive due to soil degradation, reduction of varieties potential and bad crop practices. In order to propose a management tool of onion production, this study has been realized in Senegal river valley growing conditions during fresh season of 2022. It allowed to evaluate different levels of cow dung (CD) as amendment and 10-10-20 as covering mineral fertilizer on onion under Split plot design with 16 treatments and 3 replications. Parameters were related to growth, bulb quality and yield. Data have been analyzed with RStudio 4.2.2 software. Results of statistical analysis showed no significant effect of treatments on parameters. However, high doses of CD and 10-10-20 led an increasing of morphological parameters. Bulb qualities improve with a half reduction of 2 types of matter excepted polar diameter and external tunic thickness which are not affected by applications. Quantities higher than 10 $t.ha^{-1}$ of CD and half of 10-10-20 allowed 38.98% raise of yield in comparison to control. Application of over 10 $t.ha^{-1}$ of CD in organic amendment and 0.5 $t.ha^{-1}$ of 10-10-20 in covering fertilization is a performant management way of onion growing system.

Keywords: *Onion, river valley, cow dung, fertilization, Senegal.*

INTRODUCTION

In Senegal river valley (SRV), onion crop is well developed since over ten years [1] with "*violet de galmi*", a variety with high production potential [2]. Yet, a main constraint caused by multiple reasons is decreasing quantitative and qualitative production [3, 4, 5]. Indeed, the use of plowing machine caused an aggressive soil plowing avoiding its biological vitality and the fundamental role of organic matter in crop system [6, 7]. Production quality is also compromised by unknown agricultural practices promoting yield instead of bulb quality [8]. The lack of cultivated varieties diversity, the use of fairly adapted seeds to climate and soil poverty by excessive chemical inputs come intensify this issue [9]. According to Chléla and Thibault [10], management of nitrogen fertilization is restrictive in organic soil because of the difficulty of predicting mineral liberation rate. It is why the non-adaptation of fertilization technics, applied quantities and problems of weeds management constitute main challenges to be raised for yield improvement and bulb quality [11]. In another side, the usage of organic matter as fertilizer or amendment can contribute to restore soil quality et increase crop yields [12]. Several studies reported that manure is an effective amendment which makes best physico-chemical and biological soil qualities [13, 14]. The integration of organic matter in onion growing system is a practice relatively frequent in SRV particularly in localities with high potential of breeders. A qualitative diagnosis realized by Mbaye and al. [15] allowed to identify types de organic matters and to establish their usage conditions in onion growing system. According to these results, cow dung is the most used as amendment and/or fertilizer and is spread with quantities less than 10 $t.ha^{-1}$ at 2 or 3 months before plants transplantation.

This study aims to participate to achieve production goals scheduled in the agricultural plan for durable food sovereignty around 2025. Specifically, it is about *(1)* to evaluate morphological characters of onion, *(2)* to estimate yield and *(3)* to appreciate quality harvest.

MATERIALS AND METHODS

Experimental site presentation

Study has been realized in the application field of High Institute for Vocational Learning (Richard Toll, Saint Louis, Senegal) located at 16°24’39’’N and 16°40’25’’O (Figure 1).

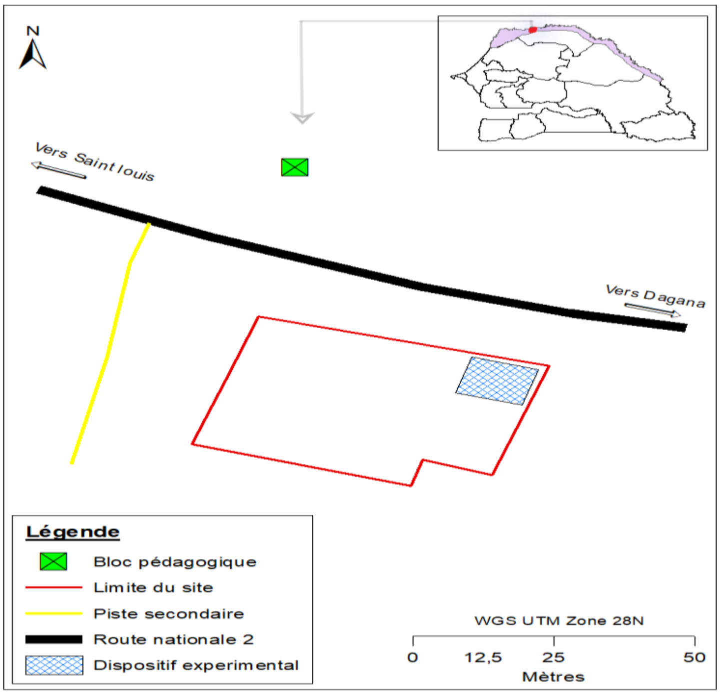

Fig. 1. *Localization of experimental site*

It is characterized by clay-sandy soil from sahelian climate [16]. Rainy season duration is 3 months (from June to October). August records more rains with 83 mm in mean. Dry season goes to 9 months (from October to June) [17]. Temperatures vary from 20 and more than 35 °C with 27 °C annual mean and 15 °C as amplitude [16].

Material

Cow dung has been used as organic amendment and 10-10-20 as mineral fertilizer. These substrata are the main matter used in soil fertility management in onion growing system of the valley [15]. Applied quantities are indicated in Table 1.

***Table 1**. Experimental treatments*

OF1_MF1 : 0 t.ha^{-1} CD + 0 t.ha^{-1} 10-10-20	OF3_MF1 : 10 t.ha-1 CD + 0 t.ha-1 10-10-20
OF1_MF2 : 0 t.ha^{-1} CD + 0.25 t.ha^{-1} 10-10-20	OF3_MF2 : 10 t.ha^{-1} CD + 0.25 t.ha^{-1} 10-10-20
OF1_MF3 : 0 t.ha^{-1} CD + 0.5 t.ha^{-1} 10-10-20	OF3_MF3 : 10 t.ha^{-1} CD + 0.5 t.ha^{-1} 10-10-20
OF1_MF4 : 0 t.ha^{-1} CD + 1 t.ha^{-1} 10-10-20	OF3_MF4***** : 10 t.ha^{-1} CD + 1 t.ha^{-1} 10-10-20
OF2_MF1 : 5 t.ha^{-1} CD + 0 t.ha^{-1} 10-10-20	OF4_MF1 : 15 t.ha^{-1} CD + 0 t.ha^{-1} 10-10-20
OF2_MF2 : 5 t.ha^{-1} CD + 0.25 t.ha^{-1} 10-10-20	OF4_MF2 : 15 t.ha^{-1} CD + 0.25 t.ha^{-1} 10-10-20
OF2_MF3 : 5 t.ha^{-1} CD + 0.5 t.ha^{-1} 10-10-20	OF4_MF3 : 15 t.ha^{-1} CD + 0.5 t.ha^{-1} 10-10-20
OF2_MF4 : 5 t.ha^{-1} CD + 1 t.ha^{-1} 10-10-20	OF4_MF4 : 15 t.ha^{-1} CD + 1 t.ha^{-1} 10-10-20

OF**: Organic fertilizer; **MF**: Mineral fertilizer; **CD**: Cow dung, **OF3_MF4 is the recommended treatment in SRV. It is the control treatment.*

Vegetal material is onion (*Violet de galmi* variety). This one comes from Niger [18] and has been introduced in Senegal at 1970 [19]. The principal interest of the variety is to be found in its adaptation capacity in this area, its good dry matter contains, its flowering aptitude and its high yield potential [2]. Other characteristics are presented in Table 2.

***Table 2**. Distinctive characteristics of Violet de galmi variety*

Name	**Form**	**Color**	**Cycle (days)**	**Weight bulb (g)**	**Potential yield (t.ha^{-1})**
Violet de Galmi	Thick and flat	Purple	120 to 130	150	50

***Source**: Niger Ministry of agriculture*

Experimental design

Split plot design was used with 3 replications. 2 factors were studied: main factor (cow dung) with 4 levels (0; 5; 10 and 15 t.ha^{-1}) and secondary factor (10-10-20) with 4 levels too (0; 0.25; 0.5 and 1 t.ha^{-1}). It makes 16 treatments by replication applied on 1.2×1.2=1.44 m². Space between replications and between main factor treatment is 0.5 m. Space between second factor treatment is 0.25 m. Design total surface is 12.1×8.95=108.295 m².

Crop growing

Nursery and organic amendment have been installed October 11. Transplantation has been done handily at 1 month after seedling. Vigorous and healthy plants were used with 15 cm by 15 cm. Irrigation is done manually with 11 liters per application and is stopped at 75% plant falling. Before fertilizer application, a weeding operation is performed to eliminate weeds. Pest attack and plant disease were not detected. Spreading of mineral fertilizer is done in 4 times: at transplanting, 20th, 40th and 60th day after transplanting. 2 weeks pre drying were observed and were followed by harvest per experimental unit (1 m²). Figure 2 shows the different operations of design setting up, crop management and harvest.

Fig. 2. *Setting up experimental design and crop growing*

***Legend**: **(a)**: setting up experimental design, **(b)**: cow dung spreading, **(c)**: plants transplanting, **(d)**: weeding, **(e)**: 10-10-20 application **(f)**: harvest area delimitation, **(g)**: bulb manual harvesting, **(h)**: leave and roots cutting.*

Measuring parameters

Parameters are defined by *Allium spp* descriptor [20]. It concerns growth (number of leave per plant, leaf length and neck diameter), bulb quality (equatorial diameter, polar diameter, bulb weight and external tunic thickness) and yield (Figure 3).

***Fig 3**. Data collecting*

***Legend**: **(a)**: number of leave, **(b)**: plant height, **(c)**: neck diameter, **(d)**: subplot production, **(e)**: equatorial diameter, **(f)**: polar diameter, **(g)**: bulb weight.*

Data treatment and analysis

Collected data have been recorded in MS Excel spreadsheet which allowed to generate graphics. Statistical analysis was performed with RStudio 4.2.2 software.

RESULTS AND DISCUSSION

Effects of treatments on morphological parameters

Results from variance analysis indicate no significant difference ($p>0.05$). Best performances were observed on 7, 4 and 9 treatments respectively on number of leave per plant, leaf length and neck diameter. OF4_MF3 treatment is the best in all morphological parameters (Table 3).

Table 3. *Variation of leave number, leaf length and neck diameter by treatments*

Treatment	Leave number	Leaf length (cm)	Neck diameter (cm)
OF1_MF1	7.6±0.655 a	39.26±3.908 a	11.92±1.75 a
OF1_MF2	7.566±0.208 a	42.07±2.04 a	11.66±1.36 a
OF1_MF3	8.33±0.351 a	38.14±2.6 a	12.09±1.51 a
OF1_MF4	7.133±1.155 a	36.92±6.4 a	10.5±2.04 a
OF2_MF1	7.167±0.503 a	35.79±4.83 a	9.7±0.87 a
OF2_MF2	6.9±1.389 a	34.06±7.47 a	8.61±2.34 a
OF2_MF3	6.633±1.877 a	26.30±15.28 a	10.13±3.04 a
OF2_MF4	7.1±0.954 a	36.16±7.14 a	10.88±2.96 a
OF3_MF1	6.733±0.503 a	37.06±7.14 a	10.27±2.24 a
OF3_MF2	7.9±1.044 a	38.96±6.38 a	11.73±2.4 a
OF3_MF3	8.5±0.3 a	42.62±1.7 a	12.7±1.06 a
OF3_MF4	7.567±0.493 a	40.01±1.86 a	10.73±0.85 a
OF4_MF1	6.933±0.907 a	32.23±9.41 a	9.7±2.92 a
OF4_MF2	8.3±0.693 a	39.11±2.99 a	12.9±1.93 a
OF4_MF3	9.033±1.662 a	43.95±8.53 a	13.2±5.68 a
OF4_MF4	8.067±1.57 a	40.88±10.59 a	11.75±4.92 a
Df	**9**	**9**	**9**
Probability	**0.579**	**0.88**	**0.899**
Signification	**NS**	**NS**	**NS**

Legend: *Results are means of 16 treatments. Means affected by the same letter in the same column do not differ significantly.* ***NS***: *Non-significant.* ***Df***: *Degree of freedom.*

Treatments with at least 10 $t.ha^{-1}$ have a very good leaf production (7 to 9 leave per plant) which overcomes control (7 leave per plant). These performances are not noticed when matter is used without mineral fertilizer (OF3_MF1 and OF4_MF1). The same situation is also observed on leave length with a quantity of organic matter up to 15 $t.ha^{-1}$ and 50% recommended chemical fertilizer (OF3_MF3). However, application of 25% of 10-10-20 without organic amendment (OF1_MF2) leads to the same result on that parameter. Concerning neck diameter, we notice a non-negligible variation when mineral fertilization is used without or with cow dung but with a dose from 10 to 15 t.ha^{-1}. Best performances of this morphological variable (over 12 cm) are obtained with a combining of over 10 t.ha^{-1} of organic matter how ever applied quantity of mineral fertilizer. These results would be linked with the practice of organic and/or mineral fertilizer. Organic matter, effectively, improves mineral composition of soil and has a positive action on onion growth [21, 22]. High quantity of cow dung combined with the usage of inorganic fertilization positively impacts crop growth as well as leave production [23]. According to Yara [24], onion requires a high level of nitrogen due to its superficial root system. Considering divided application of 10-10-20 during trial and the nitrogen richness of cow dung spread 3 months before transplantation, this practice should provide enough nitrogen minerals to crop for its growth needs. Indeed, an adequate application of nitrogen is crucial during all the crop cycle [25]. Searchers as Orgnalaga and al. [26] indicated a profitable effect of cow dung in combining with NPK fertilizer and urea on cassava growth and development. This action could justify recorded performances for OF3_MF3, OF4_MF3 and OF4_MF4 treatments on all onion morphological parameters.

Effects of treatments on crop yield

Results show that treatments have no significant effect (p>0.05). Yields vary from 3.24 to 11.16 t.ha^{-1}. Means histogram indicates that 9 treatments obtained best results compared to control (5.55 t.ha^{-1}). Best yield were observed with OF4_MF3 treatment (11.16 t.ha^{-1}). It is followed by OF4_MF4 (8.71 t.ha^{-1}), OF1_MF3 (7.81 t.ha^{-1}) and OF3_MF3 (7.71 t.ha^{-1}) treatments (*Figure 4*).

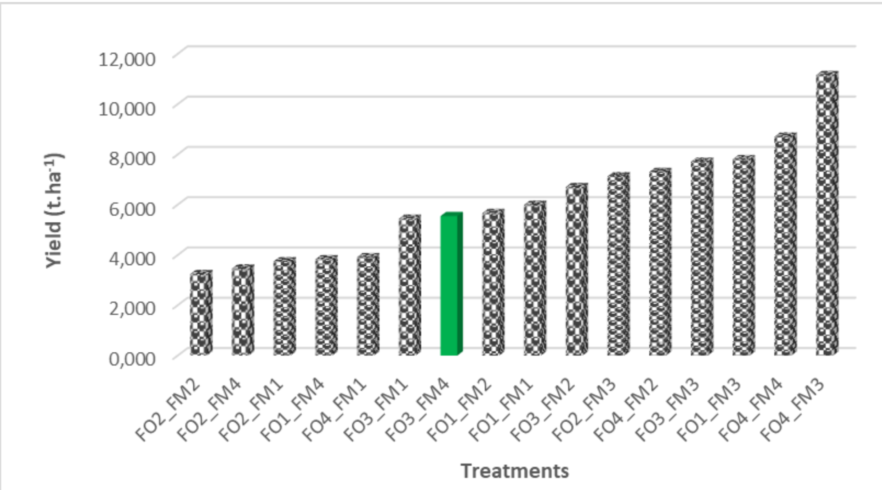

Fig. 4. Variation of yield by treatments

Crop yield varied a lot despite nonexistence of significant effects of treatments. Spreading of variable quantities from 0.25 to 1 t.ha^{-1} of 10-10-20 with cow dung (from 10 to 15 t.ha^{-1}) allowed to have best bulb productions. Higher yield varied from 6.7 to 11.16 t.ha^{-1} depending on applied doses even mineral or organic. This variation could be explained by combined effects mineral fertilizer and cow dung on soil fertility. Indeed, the combination of these substratum improves soil chemical fertility which cause directly plant growth and crop yield [27, 28]. For Bakayo and al. [29], cow dung application is quantitatively profitable to onion mainly with increasing doses. Thanks to its nitrogen contain, this type of substrate allows to get good yield for many crops [30]. In addition to it mineral composition, cow dung reduces minerals decrease which will be available for crops [31]. Other similar results have been reported about structural stability, water retention capacity and improvement of soil biological activity. Willumsen and Thorup-kristensen [32], Orden and al. [33] and Mounirou [34] reported a very high significant effect of organic fertilizers on soil hydrogen potential (pH), mineral contain (N, P and K) and exchangeable bases (Ca^{2+} and Mg^{2+}). Thus, these results should explain bad yield noticed on subplot without amendment or with low organic matter quantity (less than 5 $t.ha^{-1}$). However, we have to notice that the control treatment recorded a result lower than some subplot without amendment or chemical fertilizer or with reduced quantity of chemical fertilizer (25%) and without amendment (OF1_MF1 and OF1_MF2).

Effects of treatments on bulb quality

Equatorial diameter, polar diameter and weight bulb variation are presented in Table 4. Analysis of variance revealed that there is no difference (p>0.05). On 16 treatments, 7 showed a best performance on equatorial dimeter, 13 on polar diameter and 7 on bulb weight. OF1_MF3 comes first in polar diameter (43.4 cm) and weight bulb (53.61 g). For equatorial diameter, it ranks the 2th position with 45.76 cm after OF3_MF3 treatment (46.47 cm).

Table 4. *Variation of equatorial diameter, polar diameter and bulb weight by treatments*

Treatment	Equatorial diameter (cm)	Polar diameter (cm)	Bulb weight (g)
OF1_MF1	38.82±2.59 a	37.3±0.1 a	31.55±4.11 a
OF1_MF2	39.45±2.97 a	37.28±1.95 a	33.37±7.22 a
OF1_MF3	45.76±9.83 a	43.4±5.13 a	53.61±28.11 a
OF1_MF4	34.30±2.59 a	36.13±0.47 a	27.77±2.19 a
OF2_MF1	37.54±9.76 a	35.77±5.23 a	33.28±18.16 a
OF2_MF2	29.9±8.34 a	33.97±4.78 a	20.59±10.96 a
OF2_MF3	42.37±16 a	41.66±7.77 a	52.33±33.88 a
OF2_MF4	36±5.19 a	33.77±3.85 a	29.05±7.81 a
OF3_MF1	37.27±7.84 a	35.5±5.72 a	28.85±13.51 a
OF3_MF2	41.80±12.98 a	36.1±6.32 a	41.99±26.42 a
OF3_MF3	46.47±6.63 a	39.27±2.5 a	52.66±17.18 a
OF3_MF4	40.30±5.86 a	35.43±4.8 a	34.28±13.51 a
OF4_MF1	34.43±9.03 a	35.67±7.08 a	28.01±16.65 a
OF4_MF2	41.13±7.7 a	37.77±3.73 a	39.66±17.61 a
OF4_MF3	42.87±13.23 a	39.67±6.41 a	45.51±32.03 a
OF4_MF4	41.83±16.62 a	39.17±11.4 a	44.06±33.22 a
Df	**9**	**9**	**9**
Probability	**0.946**	**0.984**	**0.956**
Signification	**NS**	**NS**	**NS**

Legend: *Results are means of 16 treatments. Means affected by the same letter in the same column do not differ significantly.* ***NS***: *Non-significant.* ***Df***: *Degree of freedom.*

Concerning bulb quality, equatorial diameter and bulb weight highly varied with combining cow dung and 10-10-20. Spreading of 50% of recommended 10-10-2020 scored the best bulb weight (51.03 g) whatever the level of cow dung. This widely overpass recorded results about control practice (34.28 g). Any observable difference was detected for singular application. That is not the case for polar diameter where best results were found with or no combining treatments. Application of 50% 10-10-20 takes first place with 43.4 cm (without amendment) and 41.66 cm (with OM at 50%). During bulb processing, there is an important increasing of water needs [35] and phosphorus of crop [36]. The rise of bulb weight with increasing quantity of 10-10-20 is linked to its phosphorus content and potassium which interfere respectively in root system development for water nutrition and bulb forming. According to Windpouiré and al. [37], phosphorus and potassium abortion is important in bulb growth stage. That is the reason why mineral fertilization advantages an increasing of bulb weight mainly with high quantities [38]. In addition, few minerals provided by cow dung could also contributes in this forming [39]. In another hand, leaf development constitutes explanation factor of this situation. Indeed, nitrogen used by plant during this stage comes essentially from leave [40]. In this trial, we remarked a good leaf production for these treatments during vegetative stage. This explain observed performances on all bulb parameters for OF1_MF3, OF2_MF3, OF3_MF2, OF3_MF3, OF4_MF1, OF4_MF2, OF4_MF3 and OF4_MF4 treatments.

Correlation between yield and other parameters

Analysis of correlation shows an influence statistically significant of other parameters on yield ($p=9.978.10^{-15}$). Neck diameter ($p=0.0034$) and bulb weight ($p=0.0002$) contributed particularly in this correlation. Pearson correlation matrix reveals a high link between parameters (*Table 5*).

Table 5. *Correlation between agro morphological parameters*

Paramter	Ne.Diam (cm)	Eq.Diam (cm)	Pol.Diam (cm)	LeafLen (cm)	Leaf Numb	Bulb W (g)	Yield ($t.ha^{-1}$)
Ne.Diam (cm)	1	0.7591	0.6745	0.8154	0.8457	0.6793	0.7821
Eq.Diam (cm)	0.7591	1	0.9059	0.759	0.7834	0.9671	0.8542
Pol.Diam (cm)	0.6745	0.9059	1	0.6917	0.6917	0.8975	0.7905
LeafLen (cm)	0.8154	0.759	0.6917	1	0.7935	0.6683	0.7106
Leaf Numb	0.8457	0.7834	0.6917	0.7935	1	0.7235	0.7481
BulbW (g)	0.6793	0.9671	0.8975	0.6683	0.7235	1	0.8698
Yield ($t.ha^{-1}$)	0.7821	0.8542	0.7905	0.7106	0.7481	0.8698	1

***Legend**: **Ne.Diam**: Neck diameter; **Eq.Diam**: equatorial diameter; **Pol.Diam**: Polar diameter; **Leaf Len**: Leaf length; **Leaf Numb**: Leave number; **BulbW**: Bulb weight; **Yield**: Yield.*

Results showed a positive correlation between parameters. The level of this link fluctuates from 0.66 to 0.99 according to Pearson coefficient. This implicates that improving growth parameters leads to the increasing of bulb quality and yield. This situation can be explained by the fact that leaf production is in link with bulb forming and consequently with crop yield. Indeed, leave number impacts onion capacity to react to environment factors which start bulb forming [41]. Furthermore, leave weakness and drying during maturation makes it conduct nutrients to bulb which implies a gain of weight and yield [41]. Results corroborate Anatole [42] and Boukary and al. [43] who reported a high correlation between plant high, leave number, calibre, bulb weight and yield.

Effects of treatments on bulb thickness

Results show that treatments have no significant effect on external bulb thickness. All bulbs have middle thickness whatever the treatment (Figure 5).

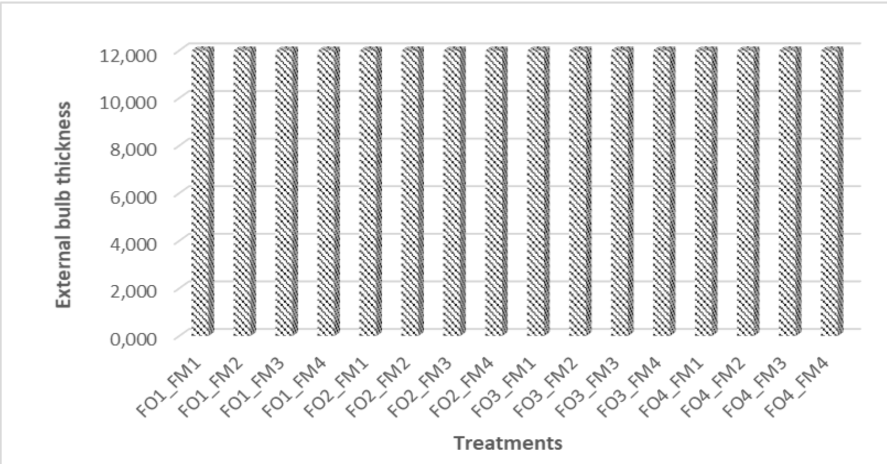

Fig. 5: *Variation of external tunic thickness by treatments*

External tunic thickness does not vary whatever treatment and any significant effect were revealed by statistical analysis. It is middle thickness according to IPGRI criteria [20] despite the good dry matter contain of violet de galmi [2]. Tunic forming starts with bulb forming and ends with plant falling [35]. Its nature is more or less linked to pre harvest drying [44] which favors a good neck firmness [24]. In this way, a delay of harvest leads to tunic loss [45] and bulb with high dry matter contain are firmer and have thicker tunic [46]. During this study, 15 days in situ drying was observed in all subplots. This may explain homogeneity of tunic for all parameters. Yet, studies showed that nitrogen acts positively on onion tunic quality through raising of specific weight [47] but becomes prejudicial with a high rate [48]. The part of nitrogen in 10-10-20 composition is relatively low (10%) especially for reduced quantities. This may not influence significantly external tunic forming and its type.

CONCLUSION

This study followed another performed about integration of organic matter in onion growing system. It allowed to appreciate effects of 4 levels of organic amendment and 4 doses of mineral fertilizer on onion agro morphological parameters and bulb quality in this agro ecological area. The objective was to contribute to level up onion production and quality with durable practice for soil fertility management. Definitely, results show statistically no difference between treatments. However, leave number, leave length and neck diameter raise up with increasing doses of amendment and mineral fertilizer. Best yield was obtained with at least 10 $t.ha^{-1}$ of cow dung and 50% of normal quantity of 10-10-20. A combining of 50% of amendment and mineral allows to improve equatorial diameter, polar diameter and bulb weight. A high correlation was observed between all parameters. Highlighting these results, spreading of over 10 $t.ha^{-1}$ of cow dung and 0.5 $t.ha^{-1}$ of 10-10-20 is an effective way to improve onion growing system.

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Conflict of Interest. The authors declared that there is no conflict of interest.

Authorship Contributions. Concept: M.M., E.F., M.A.T., A.B., Design: M.M., E.F., Data Collection: M.M., M.D., Analysis or Interpretation: M.M., E.F., M.A.T., A.B., M.D., Literature Search: M.M., M.D., Writing: M.M, E.F, M.A.T, A.B., M.D.

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REFERENCES

[1] David-Benz, H., Seck A. (2018): Améliorer la qualité de l'oignon au Sénégal: contractualisation et autres mesures transversales. Rapport d'analyse de politique, Rome, FAO, 77p.
[2] De Bon, H., Pagès, J., Ba, M. L. (1992): La culture de l'oignon dans la moyenne vallée du fleuve Sénégal. Onion Newsletter for the Tropics (4): p 6-10.
[3] Ba, D., David-Benz, H., Hult, J. (2001): Quelques éléments d'analyse sur les itinéraires techniques pratiqués par les producteurs d'oignon de la vallée du fleuve Sénégal. Document PSI-Sénégal, ISRA (Saint-Louis). 15p.
[4] Van-Vugt, S., Salifou, L., Douma, A., Daddy, A., Ouedraogo, Z., Sarr, M., Adjobo, R. A., Schrader, T., De Roo, N. (2010): Pour une filière nigérienne de l'oignon compétitive et inclusive. Wageningen University, Niger, 63p.
[5] Arnoldus, M., Kyd K., Chapusette, P. (2021): Senegal Agricultural Value Chain Study. 180p.
[6] Pagès, J. (1995): Les systèmes de culture maraîchers dans la vallée du fleuve Sénégal. Pratiques paysannes, évolution. In: Nianga, laboratoire de l'agriculture irriguée en moyenne vallée du Sénégal. ORSTOM, ISRA. Paris, ORSTOM, pp. 171-187.
[7] Huber, G. et Schaub, C. (2011): La fertilité des sols: L'importance de la matière organique. Service Environnement-Innovation, chambre d'agriculture bas-rhin. 41p.
[8] Yechou, K. Enghien, N. B. (2020): Travail de recherche: la question du développement, au sein de la filière Sénégalaise de l'oignon, 45p.
[9] PAPA (2018). Filière oignon, le paradoxe Autosuffisance / importations, projet d'appui aux politiques agricoles, 2p.
[10] Chléla, C. et Thibault, E. (2005): Rationalisation de la fertilisation azotée de la laitue en sol organique. Direction de l'innovation scientifique et technologique du Ministère de l'Agriculture, des Pêcheries et de l'Alimentation. Programme de soutien à l'innovation horticole, pp 4-27.
[11] Ghosheh, H. Z. (2004): Single Herbicide Treatments for Control of Broadleaved Weeds in Onion (Allium cepa L.). Crop Protection, pp. 539-542.

[12] Fall, N. K. (2021): Effet de la période d'application de la matière organique sur la culture de l'oignon (Allium cepa) dans la cuvette de Lac kalassane, Mémoire de fin d'études Université Gaston Berger de Saint louis (Sénégal), 30p.
[13] Calmets, I. (2009): Bien choisir les engrais naturels, Éditions Artémis pour la présente édition, Losange, Français; ISBN-10: 2844168770; ISBN 13 978 28441687. 48p.
[14] Tejada, M., Hermandez, M. T. and Garcia, C. (2006): Application of two organic amendments on soil restoration: Effects on the soil biological properties. Journal. Environ. Qual. 35, pp. 1010-1017.
[15] Mbaye, M., Faye, E., Touré, M. A., et Ba, A. (2022): Analyse diagnostique de l'utilisation de la matière organique dans les systèmes de culture d'oignon (Allium cepa L.) de la vallée du fleuve Sénégal. Afrique science, 20 (6) 136 – 149.
[16] Ba, M. (1977): Rapport d'études et de recherches pour la maitrise de géographie, l'utilisation de l'eau à Richard Toll, 46p.
[17] Weatherspark (2019): Climat et moyennes météorologiques tout au long de l'année pour Richard-Toll. Consulté le 8 avril 2023 via l'adresse https://weatherspark.com/y/31690/Average-Weather-in-Richard-Toll-Senegal-Year-Round.
[18] Nabos, J. (1976): L'amélioration de l'oignon (Allium cepa L.) au Niger, L'Agronomie Tropicale, pp. 387-397.
[19] Mauboussin, J. C. (1974): Problèmes majeurs posés par la tomate et l'oignon au Sénégal. Résultats acquis et possibilités d'action de sélection. Réunion sélection tomate et oignon à Bobo-Dioulasso, Ministère du Développement Rural, CNRA, Bambey (Sénégal), 7p.
[20] IPGRI (2001): Descriptors for Allium (Allium spp.). International Plant Genetic Resources Institute, Rome, Italy; European Cooperative Programme for Crop Genetic Resources Networks (ECP/GR), Asian Vegetable Research and Development Center, Taiwan. ISBN 92-9043-506-2.
[21] Kpera, A., Gandonou, C. B., Aboh, A. B., Gandaho, S. et Gnancadja, L. S. (2017) : Effet de différentes doses de bouse de vache, d'urine humaine et de leur combinaison sur la croissance végétative et le poids des fruits de l'ananas (Ananas comosus (L.) Merr.) au Sud Bénin. Journal of Applied Biosciences. pp.10761-10775.
[22] Falodun, E. J. and Egharevba R. K. A. (2018): Influence of poultry manure rates and spacing on growth, yield, nutrient concentration, uptake and proximate composition of onion (Allium cepa L.). Not Sci Biol, 2018, 10 (1): 117-123.
[23] Berman, H. K., Siddiqui, M. N., Siddique, M. A., Roni, M. S. and Nuruzzaman, N. (2013): Combined effect of organic manure and potassium on growth and yield of onion cv. Bari piaz-i. Int. J. Agril. Res. Innov. Tech. 3 (1): 47-51.
[24] Yara (2021): Gestion de la nutrition de l'oignon et de l'ail. Consulté le 8 mars 2023 via l'adresse https://www.yara.fr/fertilisation/solutions-pour-cultures/oignon-ail/gestion-nutrition/
[25] Zink, F. W. (1966): Études sur le taux de croissance et l'absorption des nutriments de l'oignon, Hilgardia 37 (8): pp. 203-218.
[26] Ognalaga, M., Odjogui, P. I. O., Lekambou, J. M. et Poligui, R. N. (2017): Effet des écumes à cannes à sucre, de la poudre et du compost à base de Chromolaena odorata (L.) King R.M. et H.E. Rob sur la croissance de l'oseille de Guinée (Hibiscus sabdariffa L.). Int. J. Biol. Chem. Sci., 9, pp. 2507- 2519.
[27] Sawadogo, J., Coulibaly, P. J. A., Bambara, F. J., Savadogo, A. C., Compaoré, E. et Legma, J. B. (2020): Effets des fertilisants biologiques sur les paramètres physico-chimiques du sol et sur la productivité de l'oignon (Allium cepa L.) dans la région du Centre Ouest du Burkina Faso. Vol 17(6) (2020) 44 - 57.
[28] Higashikawa, F. S., Silva, C. A., Carducci, C. E., Jindo, K., Kurtz, C., De Araújo, E. R., Resende, R. S. and Alves, D. P. (2021): Effects of the application of biochar on soil fertility status, and nutrition and yield of onion grown in a no-tillage system, Archives of Agronomy and Soil Science, DOI: 10.1080/03650340.2021.1978073.

[29] Bakayoko, S., Abobi, A. H. D., Konate, Z., Toure, N. U. (2019): Effets comparés de la bouse de bovins séchée et de la sciure de bois sur la croissance et le rendement du maïs (Zea mays L.). Université Jean Lorougnon Guédé. UFR Agroforesterie (Côte d'ivoire). p Agronomie Africaine N° Spécial (8) / AGRIEDAYS 2019, pp. 63-72.
[30] Christophe, J. D. (2016) : La bouse : historique, importance et écosystème. Thèse pour le doctorat Vétérinaire: Diplôme d'Etat Ecole National Vétérinaire de Toulouse (France), 12p.
[31] Chabbi, A., Lemaire, G. (2008): Rôles des matières organiques des prairies dans le cycle de l'azote et impact sur la qualité de l'eau., Hal-02669111 pp. 441-452.
[32] Willumsen, J. and Thorup-Kristensen, K. (2001): Effects of Green Manure Crops on Soil Mineral Nitrogen Available for Organic Production of Onion and White Cabbage in Two Contrasting Years. Danish Institute of Agricultural Sciences, Department of Horticulture (Denmark). Biological Agriculture and Horticulture, Vol. 18, pp. 365-384.
[33] Orden, L., Ferreiro, N., Satti, P., Navas-Gracia, L. M., Chico-Santamarta, L. and Rodríguez, R. A. (2021): Effects of Onion Residue, Bovine Manure Compost and Compost Tea on Soils and on the Agro ecological Production of Onions. Agriculture, 11, 962. https://doi.org/10.3390/agriculture11100962.
[34] Mounirou, M. M. (2022): Effet comparé de la fertilisation à base de biochar, engrais organique et engrais chimique sur les éléments minéraux et la production de l'oignon (Allium cepa L.). European Scientific Journal, ESJ, 18 (24), 47p.
[35] CGERV (2014) : Analyse Économique sur la filière Oignon au Sénégal, 13p.
[36] Tarpaga, W. V., Oblé, N., Rouamba, A., Zoumbiessé, T. (2011): Influence de la saison de production des bulbes et de la maturité des graines sur les caractéristiques physiologiques de la graine de l'oignon (Allium cepa L.), variété « Violet de Galmi ». Journal of Animal & Plant Sciences (JAPS), 9(2): pp1169-1178.
[37] Windpouiré, M. V. T., Oblé, N., Rouamba, A., Zoumbiessé, T. (2011): Influence de la saison de production des bulbes et de la maturité des graines sur les caractéristiques physiologiques de la graine de l'oignon (*Allium cepa L.*), variété « Violet de Galmi». Journal of Animal & Plant Sciences (JAPS), 9(2): pp. 1169-1178.
[38] Bello, S., Ahanchede, A., Amadji, G., Gbehounou, G. et Aho, N. (2012): Effet de la fumure minérale sur l'enherbement et la production de l'oignon (Allium cepa L.) au Nord-Est du Bénin. Int. J. Biol. Chem. Sci. 6(6): pp. 4058-4070.
[39] Ali, M., Khan, N., Khan, A., Naeem, R. A., Khan, M. W., Khan, K., Farooq, S. and Rauf, K. (2018): Organic manures effect on the bulb production of onion cultivars under semiarid condition. Pure and Applied Biology. Vol. 7(3), pp. 1161-1170.
[40] Bennacer, M., Bouderbala, A. (2016) : Etude du désherbage (chimique et manuel) en pépinière sur la culture d'oignon (Allium cepa L.). Département d'agronomie, mémoire de fin d'études pour l'obtention du diplôme de master en agronomie (Bourkina Fasso), 57p.
[41] Leblanc, M. (1996: Physiologie de l'oignon, comprendre la plante pour bien la cultiver. Support de communication pour conseil agricole (Québéc, Canada), 22p.
[42] Anatole, Z. A. (2012): Expérimentation agronomique sur la fertilisation de la culture d'oignon « Allium cepa L. » avec le guano barren cas d'anevoka, Mémoire de fin d'étude en vue d'obtenir le diplôme d'ingénieur agronome, école supérieure des sciences agronomiques département agriculture promotion Avana, 56p.
[43] Boukary, H., Hoaugui, A., Barage, M., Adam, T. (2013): Evaluation agro-morphologique des variétés et/ou écotypes locaux d'oignon du Niger. Journal Article, 6(6), pp. 3098- 3106.
[44] Boudache, M., Winden, Y. V., Winden, M. A. V. et Guérin, J. C. (2014): Itinéraire technique de l'oignon cultivé en sol organique pour les producteurs horticoles et les conseillers agricoles, 25p.
[45] Wall, A. D. and Corgan, J. N. (1999): Yield and dry weight of dehydrator onions after uprooting at maturity and delaying harvest. American Society for Horticultural Science 1999. Volume 4 (6), 1068-1070.

[46] ONCA (2015): Elaboration des référentiels techniques et technico-économiques. Phase 3: élaboration des référentiels techniques et technico- économiques spécifique à la filière. Cas de la filière des cultures maraichères. Guide pratique pour les conseillers agricoles (Maroc). Version définitive 471-N1077-18b, 65p.

[47] Yara (2023): Fertilisation de l'oignon et de l'ail: Amélioration de l'aspect et de l'état de la tunique des oignons. Consulté via https://www.yara.fr/fertilisation/solutions-pour-cultures/oignon-ail/amelioration-aspect-etat-tunique-oignons/

[48] Landry, C., Joseph, C-A., Houde, S., Forest-Drolet, J. et Grenier, M. (2022): Fertilisation de l'oignon espagnol en sol minéral. Mandat IRDA de révision des valeurs scientifiques de référence en fertilisation du Québec. Fascicule: Oignon espagnol, Version finale, 75p.