International Research Journal of Biological Sciences ISSN 2278-3202
Vol. 4(12), 46-53, December (2015) Int. Res. J. Biological Sci.

Effects of Seed orientation and sowing depths on Germination, Seedling vigor and yield in Oleaginous type of Bottle gourd, *Lagenaria siceraria* (Molina Standl)

Koffi Kouamé Kevin[1*], N'goran Koffi Bernard[1], Kouakou Kouakou Laurent[1], Kouassi Kouadio Ignace[1], Baudoin Jean-Pierre[2] and Zoro Bi Irié Arsène[1]
[1]Université Nangui Abrogoua. Department of Natural Sciences, Laboratory of Genetics. 02 BP 801 Abidjan 02, CÔTE D'IVOIRE
[2]University of Liège, Gembloux Agro-Bio Tech (GxABT). Unité de Phytotechnie Tropicale et Horticulture, Passage des Déportés 2, B-5030 Gembloux, BELGIQUE

Available online at: www.isca.in, www.isca.me
Received 4th November 2015, revised 22nd November 2015, accepted 9th December 2015

Abstract

Lagenaria siceraria *is most prized in African society. But its production remains low due to low rate of germination and bad seedling vigor. Use of a good sowing technique could contribute to increase germination rate and seedling vigor. In this context optimization of seeds orientation and sowing depth are essential in cultural practices. This study was conducted to determine the appropriate sowing depth and seed orientation for a good germination, seedling vigor and best yield. Three sowing depths (2 cm; 6 cm; 10 cm) and four orientation (vertical with the extremity of the seed upward (VU); or with the extremity of the seed downward (VD); horizontal with the seed on the side (HS); with the seed on the flattened face (HF)) were tested. According to seed orientation, germination was better in horizontal position, but the best seedling vigor was recorded with vertical position VD. The highest grain yield was obtained in vertical position VU. Concerning sowing depth results showed that germination was better when seeds were sown at 2 cm. But plants were stronger at sowing depth 10 cm. The highest grain yield was recorded at sowing depth 10 cm too. But best results were recorded with combination HF and sowing depth 10 cm.*

Keywords: Lagenaria siceraria, seed orientation, sowing depth.

Introduction

Oleaginous type of bottle gourd, *Lagenaria siceraria* (Molina Standl.) is one of the most minor crop widely distributed and consumed products in both rural and urban areas in sub-Saharan Africa. It is an important crop which provides high quality protein for many resource poor inhabitants in West Africa[1]. It exhibits the richest macronutrient contents and contains 34% proteins and 50% fat[2]. It is an economically important crop because of the price of a kilogram of shelled seeds in urbain markets (2.27 euro/kg). On the other hand *L. siceraria* is cultivated for its high agronomic potential[3]. Despite its importance as a traditional food security crop and its emergence as a commercial crop, *L. siceraria* cultivation encounters several constraints. Culture is still traditional. The crop is largely produced by poor smallholder farmers with the aid of hoe resulting in poor performance. Low yield has generally been attributed to poor soil crusts, insufficient soil moisture, low soil temperature, nonviable seed, which reduce or retard seedling emergence. But observations from an unrelated field experiment indicated a possible relationship between emergence and seed orientation or sowing depth. They are important factors in crop management practices[4]. Germination is the first developmental step in the life cycle of a plant to produce a new generation and the ability to accomplish this task is a prerequisite to start this cycle[5]. To ensure good germination, rapid emergence and good performance, seeds must be placed in a position and in an environment that ensures the availability of nutrients and water from the soil[6]. Seed orientation affect greatly seedling emergence. Sowing depth can greatly influence cucurbitacea' ability to emerge and establish a uniform stand. It is important to plant accurately in order to achieve good germination, emergence and high plant population[7].

The depth of sowing is important in maximising the potential of seedling emergence and crop yield[8]. It has been reported that increasing sowing depths can enhance crop establishment because of the higher soil-water content in the seed zone, resulting in better germination and emergence of seedlings[9-15]. Deeper sowing also reduces the number of seeds removed by birds and mice[16]. Information about sowing depth and seed orientation improved initial growth, development and yield of some crops[17].

The evaluation of the agronomic potential of *Lagenaria siceraria* must take into account the cultural practices. Data gathering can allow the implementation of germplasm management strategies, improve cultivation practices as well as promote cropping. This study, therefore, is aimed at investigating the effects of seed orientation and sowing depth on germination, seedling vigor and yield of *Lagenaria siceraria.*

Material and Methods

Plant material: Seeds of *Lagenaria siceraria* from Nangui Abrogoua University (Abidjan, Côte d'Ivoire), collection recorded to alpha-numeric code NI304 were used for this study. Based on standard deviation of mean weight of 500 seeds (0.148 ± 0.026 g) seeds whose weights were between 0.122 g and 0.174 g were selected. Seeds within this range of weights were used because variation of seed weight of a species may affect the germination and seedling vigor.

Study site and Experimental design: The experiment was conducted in two growing seasons; major (April To July) and minor (September To October) rainy seasons of two years 2007 and 2009 at the Nangui Abrogoua experimental station located between latitudes 5°17'N and 5°31'N and longitude 3°45'W and 4°31'W. Climate of the experimental site falls within the semi-deciduous forest agro-ecological zone with an average annual rainfall > 2.000 mm. The average daily temperature is 28°C, with annual amplitude of 5-10°C. The study area is a fallow land mainly covered by *Chromolaena odorata* (L.) King and H.E. Robins (Asteraceae) and *Panicum maximum* Jacq. (Poaceae). The soil structure is more or less deep, well developed with low proportion of stones ranging from 24 to 37%. This soil is rich in organic matter and very weakly acidic (pH 5-7) in the surface horizons.

Two experiments were conducted with following objectives: Evaluate seed germination power and seedling vigor on the field using a completely randomized block design with two blocks and four treatments (plots of 1 m × 0.5 m) per block. Blocks were spaced 2 meters apart. Each plot received 20 seeds, resulting in 80 seeds per treatment per block. The seed samples were sown at three different depths (2 cm, 6 cm, and 10 cm) and a spacing of 10 x 10 cm. Four sowing orientations were designed (figure-1). Vertical orientation with the extremity of the seed upward (VU). Vertical orientation with the extremity of the seed downward (VD). Horizontal orientation with the seed on the side (HS). Horizontal orientation with the seed on the flattened face (HF). Evaluate plant yield. The field lay out was a completely randomized design, with three replications. Each replicate consisted of a 24 m x 21 m plot containing 120 plants. A total of 12 treatment (VU 2; VU 6; VU10; VD 2 VD 6, VD 10, HS 2, HS 6, HS 10, HF 2, HF 6, HF 10) from combination of four seed orientation and three sowing depths were applied. The planting distance was 3 m between and 2 m within rows with 3 m of edges. Two consecutive plots were spaced by 3 m.

Parameters measured: Nine parameters were measured for germination and seedling vigor evaluation according to orientation or sowing depth. Seed germinability was evaluated using, germination time (GeT), germination percentage (GeP) and germination speed index (GSI)[18-25]. Seeds were considered germinated when the cotyledons appeared above the ground level. The seeds sown were surveyed daily for 14 days (ISTA, 1996). Seedling vigor was examined using the following parameters: Length of the hypocotyl (LgH), Length of the stalk of the seedling (LgT), Emergence time (EmT), seedling Emergence percentage (EmP), Emergence speed index (ESI) and Seedling dry biomass (SDB, measured after drying the seedling to constant weight). A seedling was considered emerged when its two cotyledonary leaves were completely opened[23]. Two phenological parameters were been measured: first male flower opening, (MFO), first female flower opening (FFO). For plant yield evaluation, six parameters were measured : number of fruit per plant (NFP), fruit weight (FWE), number of seed per fruit (NS), 100-seeds weight (100-SWE), seed weight per fruit (SWF), harvest index (HI). Calcul and measure procedure were performed according to previous studies[23-27].

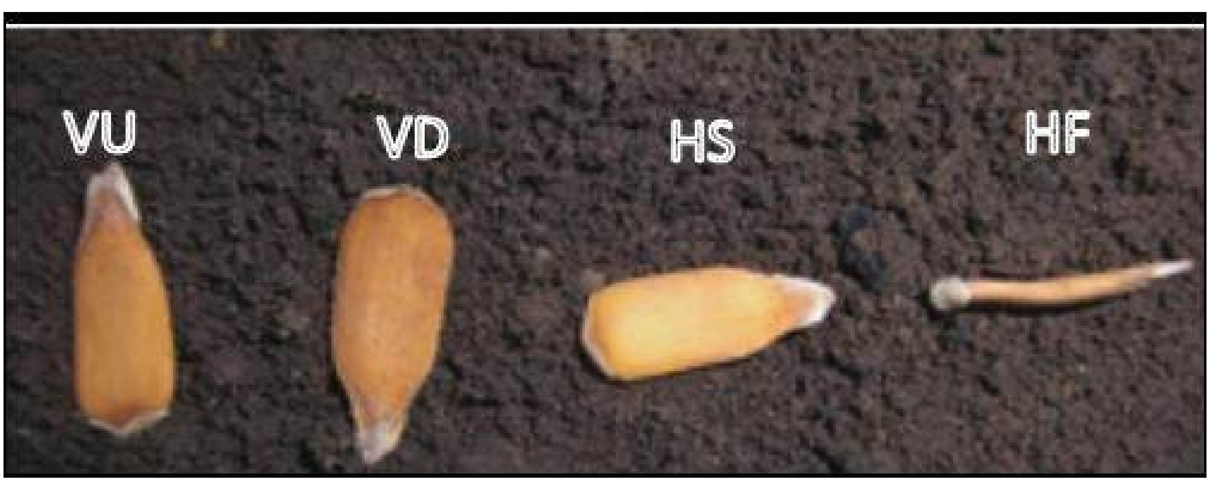

Figure-1

Seeds orientation on seedbed, VU: Vertical orientation with the extremity of the seed upward;VD: Vertical orientation with the extremity of the seed downward; HS: Horizontal orientation with the seed on the side; HF: Horizontal orientation with the seed on the flattened face

Statistical analysis: Multivariate analysis of variance (MANOVA) was performed with SAS software package (SAS 1999)[23] to investigate the difference between the four seed orientation and between the three sowing depth both germination and seedling vigor evaluation and plant yield. When the null hypothesis related to the MANOVA was rejected, Duncan's multiple range tests were carried out at α= 0.05 to identify significant differences among the means of the parameters examined.

Results and Discussion

Effects of orientation of seed: Germination: Table-1 presents values of parameters measured under the four different orientations of seed. A significant effect ($P<0.05$) on germination was observed for all parameters according to seed orientation. Seeds germination was most rapidly when seeds have been sown in horizontal position (HF and HS). The germination percentage (GeP) was also highest in the horizontal position. The smallest germination speed index (GSI) has been observed when seeds were sown in vertical orientation with the extremity of the seed downward (VD). There is no difference between the three other orientation for germination speed index (GSI).

Seedling vigor: Four (EmT, EmP, LgH, LgT) out of six parameters measured showed a difference according to seed orientation (table-1). For emergence time, difference was attributed to orientation VD which was higher than the three other. Seed in orientation VD took more time to emerge. There is no difference between both horizontal position (HF, HS) and VU. Concerning emergence percentage (EmP), the best value was observed with horizontal orientation with the seed on the flattened face (HF). For length of the hypocotyl (LgH) and length of the stalk of the seedling (LgT) the highest value was obtained in vertical orientation with the extremity of the seed downward (VD). The smallest value was noted with position VU. There is no difference between horizontal position (HS and HF).

Phenological and Yield component: There is no difference according to seeds orientation for first male flower opening, (MFO) and first female flower opening (FFO). Difference ($P<0.05$) was recorded for one parameter of yield out of six measured: number of seeds per fruit (NS). The highest value was observed when seed was placed in vertical position, with the extremity upward (VU) (table-1).

Effects of sowing depth: Germination: there is statistically significant difference between the three sowing depths for two germination parameters (GeT and GSI) out of three studied. For germination time, with the 2 cm sowing depth, germination was most rapidly followed by the 6 cm and 10 cm. The best germination speed index was observed with 2 cm and 6 cm sowing depths (table-2). There was no significant difference between the three sowing depths regarding germination percentage (GeP).

Seedling vigor - significant difference was observed between sowing depths for 4 parameters out of 6 measured (table-2): emergence time (EmT), length of the hypocotyl (LgH), length of the stalk of the seedling (LgT), seedling dry biomass (SDB). Emergence time was shorter for 6 cm sowing depth followed by 2 cm and 10 cm. Significant sowing depth effect on length of the hypocotyl (LgH), length of the stalk of the seedling (LgT) and seedling dry biomass (SDB) were observed in the order 2cm < 6 cm <10 cm.

Phenological and Yield component- No significant difference was recorded to phenological parameters (MFO and FFO). Difference was noted in number of seeds (NS) only regarding yield component (table-2). This difference was attributed to the sowing depth 10 cm which presented the highest value.

Interaction between seed orientation and the sowing depth: Table-3 shows results of interaction effects of seed orientation and sowing depth.

Germination: Combination of seed orientation and sowing depth has no effect on the three parameters expressing seed germination power i.e. germination time (GeT), seed germination percentage (GeP) and germination speed index ($P>0.05$).

Seedling vigor: Significant effect of the interaction between seed orientation and sowing depth was observed for four out of six parameters analysed: emergence time (EmT), length of the hypocotyl (LgH), length of the stalk of the seedling (LgT), and seedling dry biomass (SDB). Emergence was most rapidly (7 days after sowing) when sowing was done at 6 cm of depth in horizontal plane with the seed on the side (HS) or vertical orientation with the extremity of the seed upward. It has been later when seed had been sown in vertical orientation with the extremity of the seed downward and at 10 cm of depth (9 days after sowing). Length of the hypocotyl (LgH) was high when seeds were sown at 10 cm of depth in horizontal orientation with the seed on the flattened face (57.17±10.20 mm). The smallest value was observed when sowing depth was 2 cm and seed in vertical orientation with the extremity of the seed upward (VU) (41.05±8.42 mm). For the stalk of the seedling (LgT) highest value was observed when sowing depth was 10 cm and seeds in horizontal orientation with the seed on the flattened face (HF) with 133.63 mm and smallest value with sowing depth 2 cm and vertical orientation with the extremity of the seed upward (VU) (56.78 mm). For seedling dry biomass (SDB), best value was indicated with the sowing depth 10 cm and vertical orientation with the extremity of the seed upward (VU) (0.28±0.06 g); the lowest value was observed at 2 cm in the same position (0.21±0.04 g).

Table-1
Values of 16 traits analyzed according to seeds orientation in *Lagenaria siceraria* and results of statistical tests

Parameters[2]		Mean values (± standard deviation)				Statistical tests	
		HF	HS	VD	VU	*F*	*P*
Germination	GeT (Days after sowing)	5.10±0.93[a]	5.02±0.96[a]	5.25±1.16[b]	5.26±0.81[b]	13.96	<0.001
	GeP (%)	88.20±18.32[a]	85.60±13.50[a]	80.60±16.31[b]	82.26±16.01[b]	2.80	0.042
	GSI (cm/days)	3.42±0.65[a]	3.48±0.72[a]	3.17±0.75[b]	3.35±0.54[a]	3.32	0.021
Seedling Vigor	EmT (days after sowing)	7.32±1.01[a]	7.29±1.09[a]	7.56±1.25[b]	7.42±1.03[a]	14.96	<0.001
	EmP(%)	86.90±11.99[a]	84.88±12.50[ab]	80.48±15.76[b]	81.43±15.89[b]	2.44	0.046
	ESI (cm/days)	2.34±0.44	2.34±0.42	2.19±0.47	2.37±0.41	2.23	0.087
	LgH (mm)	55.76±12.40[b]	55.84±12.36[b]	57.47±12.21[a]	53.85±11.94[c]	10.30	<0.001
	LgT (mm)	103.90±30.33[b]	104.41±29.80[b]	113.20±29.97[a]	100.10±30.40[c]	86.13	<0.001
	SDB (g)	0.28±0.06	0.28±0.06	0.28±0.06	0.28±0.06	1.54	0.201
Phenological	MFO (days after sowing)	36.50±3.34	36.50±3.52	36.75±3.68	36.81±3.61	0.32	0.814
	FFO (days after sowing)	50.51±5.88	50.27±6.49	50.42±6.36	50.81±5.70	0.30	0.822
Yield	NFP	5.56±4.19	4.47±3.10	5.49±4.12	4.92±3.63	1.84	0.138
	FWE (kg)	0.86±0.28	0.87±0.31	0.86±0.27	0.90±0.31	0.76	0.515
	NS	265.76±77.00[b]	260.64±80.26[b]	262.40±73.55[b]	277.82±76.06[a]	3.08	0.026
	SWF (g)	35.39±13.84	35.28±14.48	36.05±13.14	38.97±14.80	2.41	0.065
	100-SWE (g)	13.07±2.89	13.38±3.05	13.57±2.65	13.79±3.12	1.01	0.388
	HI	44.67±16.34	43.51±15.90	43.11±14.64	45.55±16.42	2.07	0.102

VU: Vertical orientation with the extremity of the seed upward; VD: Vertical orientation with the extremity of the seed downward, HS: Horizontal orientation with the seed on the side, HF: Horizontal orientation with the seed on the flattened face. GeT: germination time, GeP: germination percentage, GSI: germination speed index, LgH: Length of the hypocotyl, LgT: Length of the stalk of the seedling, EmT: emergence time, EmP: seedling emergence percentage, ESI: emergence speed index, SDB: seedling dry biomass, MFO: first male flower opening, FFO: first female flower opening, NFP: number of fruit per plant, FWE: fruit weight, NS: number of seed per fruit, 100-SWE: 100-seeds weight, SWF: seed weight per fruit, HI: harvest index. Mean values within rows by parameter followed by the same superscripted letter were not significantly different at $p = 0.05$ level, on the basis of the least significant difference test

Table-2
Values of 16 traits analyzed according to sowing depth in *Lagenaria siceraria* and results of statistical tests

Parameters[2]		**Depth**			**statistical tests**	
		2cm	**6cm**	**10cm**	***F***	***P***
Germination	GeT (Days after sowing)	4.83±0.94[a]	5.14±0.85[b]	5.51±1.03[c]	120.29	<0.01
	GeP (%)	83.75±15.23	85.35±12.85	84.28±13.36	0.02	0.979
	GSI (cm/days)	3.54±0.72[a]	3.36±0.55[a]	3.15±0.71[b]	4.60	0.011
Seedling Vigor	EmT (days after sowing)	7.40±1.10[b]	7.23±1.06[a]	7.56±7.56[c]	20.78	<0.001
	EmP(%)	83.30±14.90	83.92±13.84	82.14±15.07	0.72	0.486
	ESI (cm/days)	2.33±0.43	2.35±0.37	2.23±0.50	1.31	0.273
	LgH (mm)	50.26±10.99[c]	56.64±11.67[b]	60.34±12.06[a]	172.92	<0.001
	LgT (mm)	73.32±14.68[c]	105.53±14.94[b]	137.84±17.33[a]	376.94	<0.001
	SDB (g)	0.25±0.05[c]	0.28±0.05[b]	0.32±0.06[a]	29.58	<0.001
Phenological	MFO (days after sowing)	36.47±3.56	36.95±3.54	36.73±3.52	0.48	0.618
	FFO (days after sowing)	50.72±6.03	50.21±6.03	50.56±6.29	0.38	0.686
Yield	NFP	5.40±3.92	4.67±3.59	5.47±3.83	2.89	0.056
	FWE (kg)	0.88±0.30	0.85±0.28	0.89±0.30	2.70	0.067
	NS	263.53±76.77[b]	262.61±73.18[b]	274.92±79.27[a]	4.20	0.015
	SWF (g)	36.28±14.37	35.84±13.54	37.42±14.48	1.72	0.179
	100-SWE (g)	13.48±2.94	13.45±2.94	13.47±2.94	0.02	0.984
	HI	43.43±14.93	44.42±15.83	44.87±16.77	1.16	0.313

GeT: germination time, GeP: germination percentage, GSI: germination speed index, LgH: Length of the hypocotyl, LgT: Length of the stalk of the seedling, EmT: emergence time, EmP: seedling emergence percentage, ESI: emergence speed index, SDB: seedling dry biomass, MFO: first male flower opening, FFO: first female flower opening, NFP: number of fruit per plant, FWE: fruit weight, NS: number of seed per fruit, 100-SWE: 100-seeds weight, SWF: seed weight per fruit, HI: harvest index. Mean values within rows by parameter followed by the same superscripted letter were not significantly different at p = 0.05 level, on the basis of the least significant difference test.

Table-3
Values of 16 traits analyzed according to interaction seeds orientation and sowing depth in *Lagenaria siceraria* and results of statistical tests

Parameters[2]	Orientation	HF			HS			VD			VU		
	Depth	2 cm	6 cm	10 cm	2 cm	6 cm	10 cm	2 cm	6 cm	10 cm	2 cm	6 cm	10 cm
Germination	GeT (Days after sowing)	4.29 ±0.69	5.05 ±0.59	5.52 ±1.13	4.51 ±1.23	5.17 ±0.96	5.44 ±10.91	4.92 ±1.18	5.62 ±1.36	6.31 ±1.58	4.76 ±0.92	5.11 ±0.62	5.53 ±0.82
	GeP (%)	91.25 ±7.44	90.62 ± 13.47	85.00 ±8.45	76.87 ±14.86	87.50 ±11.01	81.25 ±14.07	79.37 ±23.66	80.00 ±12.53	90.62 ±4.95	77.50 ±1.10	80.00 ±21.041	85.62 ±12.37
	GSI (cm/days)	3.30 ±0.82	3.27 ±0.29	3.02 ±0.79	3.17 ±0.36	3.24 ±0.90	3.23 ±0.77	3.38 ±0.54	3.32 ±0.50	3.35 ±0.88	3.09 ±0.76	3.32 ±0.61	3.50 ±0.28
Seedling Vigor	EmT (days after sowing)	7.06 ±0.98^{de}	7.26 ±0.88^{de}	7.59 ±1.24^{c}	7.38 ±1.42^{cd}	6.99 ±0.97^{e}	7.68 ±1.77^{bc}	7.70 ±1.38^{bc}	7.95 ±1.67^{b}	8.54 ±1.45^{a}	7.5 0±1.10^{cd}	7.03 ±1.07^{e}	7.49 ±1.18^{cd}
	EmP (%)	85.62 ±9.42	85.00 ±11.95	80.62 ±18.60	75.62 ±11.78	82.50 ±18.70	78.75 ±13.56	77.50 ±20.35	80.00 ±13.36	89.37 ±6.23	73.12 ±18.88	78.75 ±23.41	77.50 ±14.14
	ESI (cm/days)	2.30 ±0.65	2.29 ±0.29	2.06 ±0.55	2.17 ±0.24	2.24 ±0.58	2.10 ±0.50	2.36 ±0.37	2.29 ±0.33	2.34 ±0.57	2.15 ±0.55	2.42 ±0.41	2.47 ±0.27
	LgH (mm)	51.34 ± 9.72^{f}	54.70 ±9.27^{ef}	57.17 ±10.20^{cd}	47.01 ±12.22^{g}	55.31 ±9.98^{e}	51.92 ±9.30^{f}	50.71 ±9.25^{f}	51.91 ±8.48^{f}	56.78 ±9.38^{cd}	41.05 ±8.42^{h}	53.56 ±10.65^{ef}	56.55 ±9.45^{d}
	LgT (mm)	67.89 ±10.49^{n}	98.83 ±11.28^{i}	133.63 ±11.9^{d}	66.57 ±13.41^{n}	102.07 ±12.9^{hi}	126.59 ±12.5^{e}	75.80 ±9.8^{lm}	106.15 ±12.2^{gh}	128.21 ±17.0^{e}	56.78 ±11.51^{o}	93.72 ±12.17^{j}	124.62 ±13.3^{e}
	SDB (g)	0.23 ±0.05^{gh}	0.25 ±0.06^{fg}	0.27 ±0.04^{e}	0.23 ±0.06^{gh}	0.24 ±0.05^{fg}	0.24 ±0.05^{fg}	0.23 ±0.006^{gh}	0.24 ±0.05^{fg}	0.23 ±0.05^{h}	0.21 ±0.04^{h}	0.24 ±0.05^{g}	0.28 ±0.06^{e}
Phenological	MFO (days after sowing)	38.46 ±2.41	39.00 ±2.13	37.83 ±2.33	38.75 ±2.82	37.82 ±2.56	39.00 ±3.14	38.03 ±3.39	39.30 ±2.65	38.06 ±2.30	38.78 ±2.43	38.89 ±2.84	39.48 ±2.53
	FFO (days after sowing)	49.57 ±4.16	49.72 ±5.18	47.06 ±4.63	49.83 ±5.60	48.48 ±6.10	48.96 ±4.55	47.46 ±5.55	50.31 ±4.27	47.43 ±3.56	48.96 ±3.64	48.32 ±4.74	50.58 ±4.13
Yield	NFP	8.66 ±5.54	5.20 ±3.28	7.33 ±4.19	6.13 ±3.04	5.76 ±3.83	6.65 ±3.19	6.86 ±3.25	6.00 ±5.08	8.03 ±5.24	6.55 ±3.74	6.92 ±4.26	6.44 ±3.86
	FWE (kg)	0.99 ±0.23^{bc}	0.81 ±0.26^{cd}	0.99 ±0.24^{b}	0.95 ±0.33^{bc}	0.86 ±0.28^{c}	0.96 ±0.30^{b}	0.83 ±0.25^{cd}	0.84 ±0.24^{cd}	0.98 ±0.29^{b}	1.08 ±0.27^{a}	0.98 ±0.26^{b}	0.88 ±0.31^{c}
	NS	279.35 ±80.2^{b}	273.55 ±60.3^{bc}	331.87 ±50.4^{a}	264.24 ±73.9^{bc}	271.15 ±66.0^{bc}	297.88 ±84.7^{ab}	269.18 ±84.5^{bc}	258.24 ±66.4^{b}	281.75 ±74.2^{ab}	303.51 ±61.3^{ab}	304.11 ±73.4^{a}	287.98 ±67.6^{ab}
	SWF (g)	39.79 ±12.51^{bc}	35.78 ±10.48^{c}	46.80 ±11.26^{a}	36.14 ±13.66^{bc}	37.45 ±11.64^{bc}	43.08 ±14.01^{ab}	39.35 ±15.21^{bc}	38.00 ±11.79^{bc}	40.55 ±12.75^{b}	46.78 ±11.80^{a}	45.82 ±13.28^{a}	40.11 ±13.01^{bc}
	100-SWE (g)	14.06 ±2.07	13.01 ±2.26	14.93 ±2.29	13.65 ±2.92	13.86 ±2.58	14.50 ±2.35	14.48 ±2.28	14.56 ±2.14	14.28 ±2.38	15.42 ±2.52	15.05 ±2.48	13.91 ±2.49
	HI	43.08 ±11.73^{bc}	50.61 ±14.81^{a}	49.51 ±15.05^{ab}	43.98 ±13.18^{bc}	49.61 ±18.77^{ab}	46.06 ±18.64^{ab}	46.53 ±17.31^{ab}	45.52 ±13.85^{ab}	42.77 ±12.48^{bc}	43.74 ±10.48^{bc}	48.28 ±17.02^{ab}	50.02 ±18.04^{a}

VU: Vertical orientation with the extremity of the seed upward; VD: Vertical orientation with the extremity of the seed downward. HS: Horizontal orientation with the seed on the side. HF: Horizontal orientation with the seed on the flattened face. GeT: germination time. GeP: germination percentage. GSI: germination speed index. LgH: Length of the hypocotyl. LgT: Length of the stalk of the seedling. EmT: emergence time. EmP: seedling emergence percentage. ESI: emergence speed index. SDB: seedling dry biomass. MFO: first male flower opening. FFO: first female flower opening. NFP: number of fruit per plant. FWE: fruit weight. NS: number of seed per fruit. 100-SWE: 100-seeds weight. SWF: seed weight per fruit. HI: harvest index. Mean values within rows by parameter followed by the same superscripted letter were not significantly different at $p = 0.05$ level. on the basis of the least significant difference test.

Phenological and yield component: No significant difference ($P > 0.05$) was observed with phenological parameters (MFO, FFO). But significant difference was recorded to 4 out of 6 parameters describing yield component: fruit weight (FWE), number of seed per fruit (NS), seed weight per fruit (SWF), harvest index (HI). The highest value of fruit weight was observed with sowing depth 2 cm and vertical orientation with the extremity of the seed upward (VU) (1.08±0.27 Kg). For number of seeds per fruit (NS) the best value was obtained with orientation HF and 10 cm of sowing depth (331.87±50.4*)*. On the other side for seed weight per fruit (SWF) the best values were observed with orientation HF combined with sowing depth 10 cm (46.80±11.26 g) or orientation VU combined with 2 cm (46.78±11.80 g). Harvest index (HI) was higher with orientation HF combined with sowing depth 6 cm (50.61±14.81) and orientation VU combined with sowing depth 10 cm (50.02±18.04).

Discussion: Germination is a process whose duration varies according to the type of seed and the local environmental conditions to which the seed is exposed. The effect of the seeds orientation and sowing depth on their germination was reported by several authors[2-11-22-26]. It could improve the germination rates and plant vigor. Our study showed that germination process and seedling vigor of *Lagenaria siceraria* were favoured when seeds are placed in horizontal position in the soil. This data set indicates that horizontal orientation of seeds is most suited. Shape of the cucurbits varieties used predisposed them to a horizontal orientation. The results are in accordance with the findings in bean[7-13], Anjan[19], and bamboo[12]. Difference between vertical and horizontal position results from the fact that in vertical orientation embryo could be in inverted position while with horizontal orientation, embryo position is more uniform. On the other hand, seeds emerged rapidly in horizontal orientation (HS and HF) or in vertical orientation but with the extremity of the seed upward (VU). This result could be attributing to the short distance between embryo and soil surface in these position. The vertical orientation with the extremity of the seed downward (VD) gives more vigorous seedlings. This result could be explained by the fact that rooting was faster and easy because radicle is downward position. But germination percentage was not affected in any treatment. This result could be due to homogenous of study site.

The results of our study showed also that germination time and germination speed are longer with increasing depth of sowing. Rapid germination was recorded with sowing depth 2 cm followed by 6 cm and10 cm treatment. Similar observations have been reported for cowpea[4]; wheat[10] and *L. siceraria*[15]. It has been also reported that germination percentage as a result of increased seeding depth regardless of soil conditions[26]. This result could be explained that distance between seedbed and soil surface was shortest at 2 cm than other treatments. At this depth there is better oxygen availability[21]. In most plants, adequate supply of oxygen must be available during germination. If the oxygen is reduced substantially, germination of most seeds is retarded[26]. Among four vigor parameters showing difference between sowing depth, high values were recorded for sowing depth 10 cm followed by 6 cm. This result indicated that the deepest sowing led to increased seedling vigor. Indeed the earlier germination of seeds sown superficially is explained by the lower elongation that must undergo the hypocotyl to reach the surface of the soil[20]. Our result was different from those reported on wheat for which the increase in planting depth can give better germination and good seedling emergence[18]. Although sowing depth has influenced seed germination and emergence, there was no significant effect on yield. Our result was different from those reported on wheat[27] where grain yields for all varieties decreased drastically with sowing depths.

This study has shown that germination of seeds depends of only one factor regardless of environmental conditions, seed orientation or sowing depth. Combination of both factors has no effect on germination parameters. But to ensure a best production of *L. siceraria,* combination of both factors is necessary and recommended. Indeed for each factor the number of seed is affected by orientation or sowing depth. In contrary a significant effect of combination of both factors on four out of six parameter describing yield was recorded. On the other hand the number of seed per fruit was higher with combination of both factors.

Conclusion

For each production system, cultural practice is an essential factor which can influence the yield in a given environment. This study has showed that germination of *Lagenaria siceraria* seeds was better in horizontal position, but the best seedling vigor was recorded with vertical position VD. The highest grain yield was obtained in vertical position VU. Concerning sowing depth results showed that germination was better when seeds were sown at 2 cm. But plants were stronger at sowing depth 10 cm. The highest grain yield was recorded at sowing depth 10 cm too. But best results were recorded with combination HF and sowing depth 10 cm.

Acknowledgement

This research was financially supported by Académie de la recherche et l'Enseignement Supérieur de Belgique (ARES, Brussels, Belgium).

References

1. Loukou A.L., Lognay G., Barthelemy J.P., Maesen P., Baudoin J.P., Zoro and Bi I.A., Effect of harvest time on seed oil and protein contents and compositions in the oleaginous gourd Lagenaria siceraria (Molina) Standl, *J. Sci. Food Agr.*, **91**, 2073-2080 **(2011)**
2. Achu M.B., Fokou E., Fosto M. and Tchounguep F.M., Nutritive value of some Cucurbitaceae oilseeds from different regions in Cameroun, *Afr. J. Biotechnol.,* **4(11)**,

1329-1334 **(2005)**

3. Zoro Bi I.A., Koffi K.K., Djé Y., Malice M. and Baudoin J.P., Indigenous cucurbits of Côte d'Ivoire: a review of their genetic resources, *Sci. Nat.,* **3(1)**, 1-9 **(2006)**

4. Cantliffe D.J., Seed germination for transplant, *Fla Agr. Exp. Sta. J.,* **8(4)**, 1-5 **(1998)**

5. Bewley J.D., Seed germination and dormancy, *Plant Cell.*, **9**, 1055-1066 **(1997)**

6. Bowers S.A. and Hayden C.W., Influence of seed rientation on bean seedling emergence, *Agron. J.,* **64**, 736-738 **(1972)**

7. Srivastava A.K., Goering C.E., Rohrbach R.P. and Buckmaster D.R., Engineering Principles of Agricultural Machines. Michigan, American Society of Agricultural and Biological Engineers, 604 Pages **(2006)**

8. Ahirwar R.K., Effect of sowing Depth on Seed germination of Butea frondosa (Roxb.), *Int. Res. J. Biological Sci.*, **4(2)**, 45-47 **(2015)**

9. Mahdi L., Bell C.J., Ryan J., Establishment and yield of wheat (*Triticum turgidum* L.) after early sowing at various depths in a semi-arid Mediterranean environment, *Field Crops Res.,* **58(1)**, 187-196 **(1998)**

10. Masilamani P., Singh B.G., Chinnusamy C. and Annadurai K., Influence of seed orientation and depth of sowing on germination and vigour of Anjan (*Hardwickia binata* Roxb), *Trop. Agr. Res. Ext.,* **2(1)**, 76-78 **(1999)**

11. Pommel B., Influence du poids de la semence et de la profondeur de semis sur la croissance et le développement de la plantule de maïs, *Agronomie*, **10(9)**, 699-708 **(1990)**

12. Power P. and Fonteyn P.J., Effects of oxygen concentration and substrate on seed germination and seedling growth of Texas wildrice (Zizania texana), *Southwest Nat.*, **40(1)**, 1-4 **(1995)**

13. Rama B.P., Effect of orientation of seed placement on seedling emergence in some species of Calamus. *Adv Biores.***, 2(2)**, 86-89 **(2011)**

14. SAS, SAS/ETS User's Guide. Cary, North Carrolina (USA), SAS Institute **(1999)**

15. Schillinger W. F., Donaldson, E., Allan, R. E. Jones, S. S. Winter wheat seedling emergence from deep sowing depths. *Agron. J.* **90**, 582-586 (**1998)**

16. Brown P.R., Singleton G.R., Tann C.R. and Mock I., Increasing sowing depth to reduce mouse damage, **(2003)**

17. Yagmur M. and Digdem K., The effects of different sowing depth on grain yield and some grain yield components in wheat (Triticum aestivum L.) cultivars under dryland condition, *Afr. J. Biotechnol.,* **8(2)**, 196-201 **(2009)**

18. Desbiolles J., Optimising Seeding Depth in the Paddock. Available Online, DOI, **(2002)**

19. Al-Maskri A.Y., Khan M.M., Iqba M.J. and Abbas M., Germinability, vigor and electrical conductibility changes in acceleratedly aged watermelon (Citrullus lanatus) seed. *Journal oseed. J. Food Agric. Environ.* **2 (3-4)**, 100-103 **(2004)**

20. Elfeel A.A., Effect of Seed Pre-Treatment and Sowing Orientation on Germination of Balanites aegyptiaca (L.) Del, Seeds *Am, Eurasian J. Agric. Environ. Sci.***, 12(7)**, 897-900 **(2012)**

21. Embaye K., Christerson L., Ledin S. and Weih M., Bamboo as bioresource in Ethiopia: management strategy to improve seedling performance (Oxytenanthera abyssinica), *Bioresour., Technol.*, **88,** 33-39 **(2003)**

22. Hayden C.W. and Bowers SA, Emergence and yield of bean planted with a seed-oriented planter, *Agron. J.,* **66,** 50-52 **(1974)**

23. Koffi K.K., Anzara G.K., Malice M., Djè Y., Bertin P., Baudoin J.P. Zoro and Bi I.A., Morphological and allozyme variation in a collection of Lagenaria siceraria (Molina) Standl, from Côte d'Ivoire. *Biotechnol., Agron. Soc. Environ,* **13**, 257-270 **(2009)**

24. Krishnasamy V., Effect of orientation of seed placement in soil on seedling emergence in some cucurbitaceous vegetables, *Seed Res.,* **20(2)**, 70-73 **(1992)**

25. Maguire J.D., Speed of germination. Aid in selection and evaluation for seedling emergence and vigor, *Crop Sci.* **2**, 176-177 **(1962)**

26. Tahere A.S., Hermenegildo G., Leocadio S.S. and Len W., Seedling vigor of rice cultivars in response to seeding depth and soil moisture, *Philipp. J. Crop. Sci.*, **30(1)**, 53-58 **(2005)**

27. Yao K.B., Koffi K.K., Baudoin M.S.J.P., Zoro Bi I.A., Effects of seed fermentation method on seed germination and vigor in the oleaginous gourd Lagenaria siceraria (Molina) Standl, *Afr. J. Biotechnol.,* **12(48)** 6723-6729 **(2013)**

28. Agboola D.A., Etejere E.O. and Fawole M.O., Effect of orientation and soil types on germination of seeds of some tropical tree species, *Seed Res.,* **21(1)**, 13-20 **(1993)**

29. Aikins S.H.M. and Afuakwa J.J., Growth and Dry Matter Yield Responses of Cowpea to Different Sowing Depths, ARPN, *J. Agric. and Biol. Sci.*, **3(5 and 6**), 50-54 **(2008)**