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Effects of Planting Modes on Yam (Dioscorea Rotundata, Poir and Dioscorea Alata L) Vine Cuttings for Mini Tubers Production

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Abstract : This study was designed to evaluate the effects of planting modes on mini tubers formation from vine cuttings obtained from white yam (*D. rotundata*) and the greater yam (*D. alata*). Four-month old vine cuttings obtained from two local cultivars (krenglè and kponan) of *D.rotundata* and two improved varieties (C18 and 140) of *D.alata* were planted following three planting modes in planting holes containing carbonized rice husk and arranged in ridges. The three planting modes were: 2nH (2-node cutting planted horizontally with the 2 nodes buried), 2nV (2-node cutting planted vertically with 1-node buried) and 3nH (3-node cutting planted horizontally with 2 nodes buried). The vine cuttings were sampled for survival percentage 14 DAP (days after planting), for number of new stems (%), for number and weight (g) of mini tubers 150 DAP. There were significant ($P < 0, 05$) differences in number and weight of tubers produced on vine cuttings of krenglè, kponan, 140 and C18. The number and weight of tubers obtained from vine cuttings planted out according to mode 3nH were significantly different ($P < 0.05$) from others planting modes.

Keywords*:* Yam, vine cutting, planting mode, tuber production

1. INTRODUCTION

Yams belong to the family of *Dioscoreaceae* and are members of the genus *Dioscorea*, which produces tubers and bulbils that are economically important in the zone of Benin, Cameroun, Côte d'Ivoire, Ghana, Nigeria and Togo (Agueguia et al., 2000). According to the same author, yam occupies a significant place among the food crops produced in those zones where it represents at least 200 cal/j in the food of 60 million inhabitants.

The tubers of *Dioscorea* have a dual function: first, as source of food for millions of people and secondly, as planting material (Hahn, 1995; Craufurd et al., 2006). Thus, a considerable part of harvest is preserved as planting stock. According to Shiwachi et al. (2005), about 25 to 50% of the harvest of yams is used as such. Thus, the cost of the planting material increases the total production cost (Onwueme, 1978; Shiwachi et al., 2005). This cost of planting material occupies more than 33% of the total cost of yam production.

Considering this large quantity of tubers or bulbils engaged as seed that could have been available for human consumption (Vander Zaag and Fox, 1981), other methods of yam propagation including vine cuttings have been developed (Njoku, 1963). Propagation using vine cuttings gives high rate of multiplication (20-50 %) without using tubers (Kikuno, 2009). The objectives of this study were to evaluate three planting modes and compare the response of some yam varieties, using a carbonized rice husk as substrate.

2. MATERIAL AND METHODS

2.1. Site of study and the experiment design

The study was conducted at the Food Crop Research Station of the National Center of Agronomic Research (CNRA), Bouaké (7° 44' N, 5°04' W), Center of Côte d'Ivoire, located in a rainforest – savanna transition zone. Two local varieties of yam *Dioscorea rotundata* (krenglè and kponan) and two improved varieties of yam *Dioscorea alata* (C18 and 140) obtained from the yam Germplasm of CNRA, were used. The vine cuttings were planted in split-plot design ridges with two replicates, where the four varieties (krenglè, kponan, C18 and 140) and three planting modes (2-node cutting planted vertically, 2-node cutting planted horizontally and 3-node cutting planted horizontally) constituted the main and secondary factors respectively. Thus, the vine cuttings of each variety were planted according to the three modes. Each planting mode was carried out on three ridges where there were 38 cuttings per ridge (that corresponds to a double-line of 19 cuttings).

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In this study, the vertical planting mode using vine cuttings with 3-nodes (3nV) was not used because it would imply that, if two nodes must be buried, the leaves of the basal node would be buried too or cut off. That design could be disadvantageous compared to the others where all the leaves remain above the ground during planting.

2.2. Preparation of carbonized rice husk

The planting substrate used for the experiment was carbonized rice husk. Carbonized rice husks are product of incomplete combustion of organic material (**Figure 1**). It is prepared by setting fire under half cut drum containing rice husk (Ayankanmi and Agele, 2010). During burning, a stick is usually used to intermittently mix it in order to achieve uniform carbonization. The carbonized rice husks are then cooled with water to prevent them from turning into ashes. Carbonized rice husk is a useful medium for planting seeds and seedlings (Komaki et al., 2002).

2.3. Vine cuttings preparation and planting

Yam tuber cuttings weighing 80-100g were planted in the field as multiplication plot on the mounds of 1m x 1m spacing in 2013. The plants were staked and chemical fertilizer was not applied. **Figure 2** shows the preparation method of vine cuttings. Apparently healthy vine cuttings were excised with scissors, (**Figure 2a**) from the plants 120 DAP (days after planting), collected in bucket containing water (**Figure 2b**) and were planted on the ridges between 8.00 and 11.00 am. The vines from middle portion of the lateral branch were prepared into 2 and 3-node cutting sizes with four and six leaves respectively.

The vine cuttings were then planted in holes of 5 cm depth filled with carbonized rice husks (**Figure 3**) and arranged on ridges of 5 x 0.5 x 0.4 m (L x l x H). Two lines of seed holes spaced by 25 cm were carried out on each ridge (**Figure 3**).

Figure 4 shows the different planting modes. Three different planting modes were used for each variety. First, 3-node cuttings were planted horizontally with only 2 nodes buried (3nH) (**Figure 4a**). Second, 2-node cuttings were planted horizontally with all the nodes buried and leaves outside (2nH) (**Figure 4b**). Finally, 2-node cuttings were planted vertically with 1-node buried (2nV), the second node and the four leaves outside (**Figure 4c**). All the planted cuttings were under a shelter of 1.5 m height, made with bamboo wood and palm leaves in order to keep moist on the ridges (**Figure 4d**). All were supplied with water and fertilizer (NPK 15.15.15). The cuttings were watered once per day at 7.30 a.m. every day if there was no rain. As fertilizer, a dose of 20 g NPK per cutting was applied 60 DAP. The shelters were removed 90 DAP to allow sunlight.

2.4. Data collection and statistical analysis

The experiment was carried out for 14 days before the data on percentage survival of cuttings being collected. The cuttings that established better and developed new stems were counted. Formations of the mini-tubers were observed 150 DAP when the leaves senesced. The mini tubers were counted and weighed per cutting. Data collected on number of living vine cuttings, number of cutting with new stems, number and weight of initiated mini tubers were subject to analysis of variance (ANOVA) and treatment means were separated using Duncan's Multiple Range Test (DMRT). A Khi Square test were performed for percentages.

3. RESULTS

3.1. Effects of planting modes on vine cuttings survival

The mean rate of living vines obtained for variety C18 (97.66%) and 140 (96.79 %.) were significantly different (P=0,031) (**Figure 5**) from those recorded for kponan (78.28%) and krenglè (64.03%). No significant difference was noted between C18 and 140. Meanwhile, kponan is statistically higher than krenglè concerning the rate of living vine cuttings. The 3-node planting mode (3nH) gave 95.21% of living vine cuttings after 14 days. This mode appeared more efficient (P =0.023) than the others [2nH (69.20%) and 2nV (65.42%)] (**Figure 5**).

A significant variety x planting mode interaction (P=0.001) was noted for cutting survival percentage (**Figure 6**). In krenglè variety the mean cutting survival percentage from the planting modes 3nH (70.10%) and 2nH (67.20%) was not significantly different; but, it was significantly higher than 54.80 % recorded for 2nV. However, in the three other varieties (kponan, C18 and 140) no significant difference was observed between planting modes.

3.2. Effects of planting modes on stem development

The number of new emitted stems was ~~a~~ significantly different according to variety (P<0.001) and planting mode (P<0.001) (**Figure 7**).

The means of percentage of new stems emitted from kponan (0.73%) and krenglè (0.92%) were not significantly different. However, these means were statistically lower than the mean rate obtained from 140 (6.58%) and C18 (29.12%). In the same way, 140 emitted significantly less new stems (6.58%) than C18 (29.12%). The planting mode with 3-node (3nH) had 14 % more cutting with stems (P=0.001) than 2nH and 2nV. The planting mode of 2nV gave a mean rate of 9.29 % new stems. This mean was significantly higher than that recorded from 2nH mode (4.61%).

A significant variety x planting mode interaction (P=0.001) was observed (**Table 1**). Indeed, for variety C18, 46.13% of vine cuttings planted according to the

3nH mode, developed new stems. Thus, it has developed 1.75% new stems more than 2nV and 3.09% more than 2nH. In variety 140, the means rate obtained from 2nV (9.21%) and 3nH (7.89%) were not significantly different. However, for the same variety (140) a significant difference between the planting modes (3nH, 2nV) and 2nH (2.63%) was observed. The results showed no significant difference between planting modes in kponan and krenglè varieties.

3.3. Effects of planting modes on mini-tuber production.

Figure 8 shows some tubers produced by vine cuttings of yam varieties used.

The mean numbers and weights of mini-tubers per cutting obtained from kponan and krenglè were not significantly different (**Figure 9**). But, the means were significantly lower than those recorded from varieties 140 and C18 (P = 0.001). Highest mean number and weight were obtained from C18 (1.73 and 36.63g). On the contrary kponan produced lowest number and weight (1.03 and 4,35g respectively) of mini-tubers. There was no significant difference between C18 and 140 in term of number of mini-tubers. However a mean weight obtained from C18 (36.63g) was statistically higher than the one produced by 140 (20.80g).

The planting mode with 3 nodes (3nH) recorded highest mean number of tubers per cutting (1.73). It was statistically higher than the mean number of tubers (1.53) produced by vine cuttings planted according to 2nV. Planting modes (3nH and 2nV) were however statistically identical to 2nH (1.65) which recorded an intermediary mean number of tubers. The best mean weight of tubers was obtained from 3nH planting mode (31.59g), being significantly higher (P=0.001) than that from the two other planting modes (**Figure 10**). The lowest mean weight per cutting (19.98 g) was recorded from 2nH. However, there was no significant difference between 2nH and 2nV from which a mean tuber weight of 24.15g was obtained.

The interaction between variety and planting mode was not significant (P=0.63) for the mean number of tubers per cutting (**Table 2**). However, 3nH produced in each variety (except kponan), the highest mean number of mini-tubers. This mean varied from 1.03 for kponan to 1.89 for C18. The lowest mean number of mini-tubers was obtained from 2nV in each variety. It varied from 0.92 for kponan to 1.63 for 140. Mean weights of mini-tubers per cutting obtained from planting modes in each variety were significantly different (P=0.009) (**Table 2**). Thus, in C18, 3nH produced highest mean weight of 48.39g compared to 2nH and 2nV which produced mean weights of 0,66g and 28,40g respectively. In varieties kponan, krenglè and 140, the mean weights of mini-tubers obtained from planting modes were not significantly different (**Table 2**).

4. DISCUSSION

In this study it was observed that vine cuttings from four yam varieties planted in carbonized rice husks following three planting modes survived, developed new stems and formed tubers.

About 68% of *D. rotundata* and 96% of *D. alata* vine cuttings planted remained alive after 14 days. These rates were higher than those reported by Behera et al. (2009) where only 34.64% of *D. alata* vines cuttings remained alive. However, the result was similar to that reported by Igwilo (2003) indicating that 71% of Obiaturugo (*D. rotundata*) vine cuttings remained alive after 14 days. Igwilo (2003) also showed that 40% Um 680 (*D. alata*) vine cutting were alive. This last rate (40%) is less than those obtained in the present study. Um 680 is known to be more vulnerable to dry weather conditions than Obiaturugo (Igwilo, 2003). This study highligts the fact that *D. alata* offers a higher rate of survival than *D. rotundata*.

The mean numbers of mini-tubers per cutting obtained from *D. rotundata* varieties (kponan and krenglè) were 1.03 and 1.12, and weighed respectively 4.35g and 5.68g. The result was in accordance with those reported by Shiwachi et al. (2005) using cuttings from seven varieties of *D.rotundata*. They found tubers weighing 3.0g ± 2.7 and 1.7g ± 0.8 per vine cutting. Nevertheless, the result obtained was higher than those reported by Ayankanmi and Agele (2010) showing that vine cuttings from TDr335, TDr 97/00940 and TDr 98/011230 produced 1.3g, 1.44g and 2.53g mini-tubers respectively. It was also lower than those reported by Kikuno (2006) where vine cuttings produced approximately 30 g mini-tuber under open field condition, varying from 2.7 to 97.7g. The difference with our results was probably due to the age of the cuttings (4 months) and the prevailing temperature (27^0C on average) during the vine propagation. The three planting modes used in this study could also explain this difference. The mean numbers of mini-tubers per vine cutting obtained from *D. alata* varieties (C18 and 140) were 1.73 and 1.72 and weighed 36.63g and 20.80g respectively. This result was higher than that published by Behera et al. (2009) indicating that vine cuttings from *D. alata* variety produced mean number of 0.78 mini-tubers weighting 2.34g. Probably, the higher number of mini tubers obtained in our study was due to the age of vine cuttings (4 months) compared to 45-day vines cuttings used by Behera et al. (2009). On the other hand it seems that *D. alata* performs better in our environment than in the others. That might explain the larger cultivation of that species in Côte d'Ivoire than in the other countries of Africa.

CONCLUSION

The use of different planting modes of yam vine cuttings has an impact on their survival and tubers production. The improved varieties (C18 and 140) and the planting mode (3nH) have a good effect on the propagation using vine cuttings. The results obtained confirm the possibility to produce tubers from vine cuttings, which tubers can be used in field as planting material in order to produce consumable yams.

However, the success of this technique remains dependent on the use of planting media like carbonized rice husks. Thus, the recourse to other planting media for replacing carbonized rice husks would be necessary. In addition, the use of some adapted root-promoting substances are necessary in order to improve the survival rate and the weight of tubers from vine cuttings. This study has taken into account only agronomic parameters. So, in futures studies, it would be interesting to assess not only the production cost of seeds which can sow one hectare, but also to stand out the socio-economic impact on Côte d'Ivoire population.

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Figure 1. Carbonized rice husk

Figure 2. Taking of vines cuttings

Figure 3: Ridges prepared for planting

Figure 4: Planting modes (a, b, c) and vine cuttings under a shelter (d

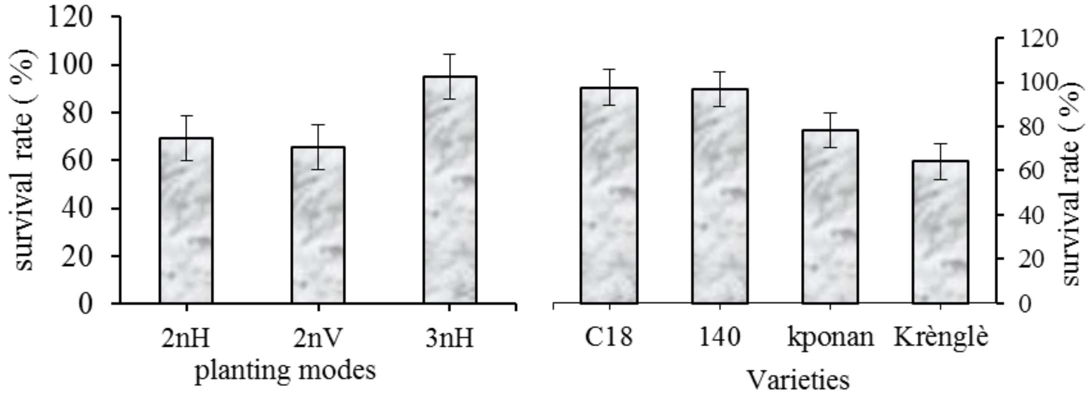

Figure 5 : Effect of planting modes and varieties on number of living vine cuttings

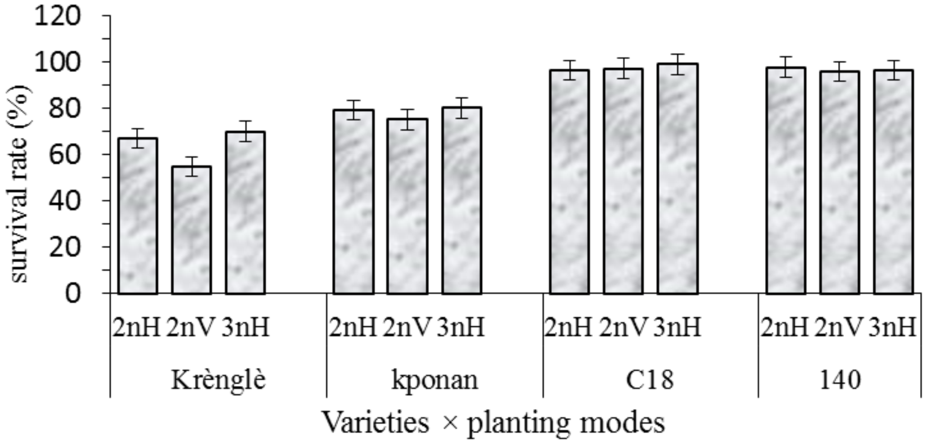

Figure 6: Effect of planting modes on yam vine cuttings varieties

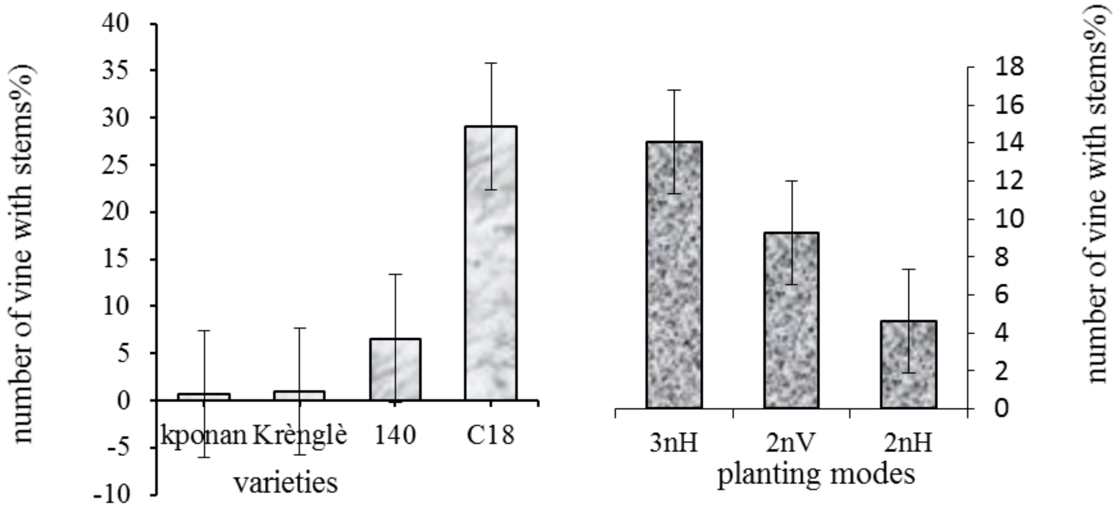

Figure 7: Effect of planting modes and varieties on number of vine cuttings with new stems

Table 1 : Effect of planting modes on varieties vine cuttings in term of vine with new stems

Varieties	planting modes	vine cuttings with new stems (%)
Kponan	2nH	$0{,}00^{a}$
	2nV	$1{,}75^{a}$
	3nH	$0{,}44^{a}$
Krenglè	2nH	$0{,}88^{a}$
	2nV	$0{,}14^{a}$
	3nH	$1{,}75^{a}$
C18	2nH	$14{,}91^{b}$
	2nV	$26{,}31^{c}$
	3nH	$46{,}13^{d}$
140	2nH	$2{,}63^{a}$
	2nV	$9{,}21^{e}$
	3nH	$7{,}89^{e}$

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test (α=0.0

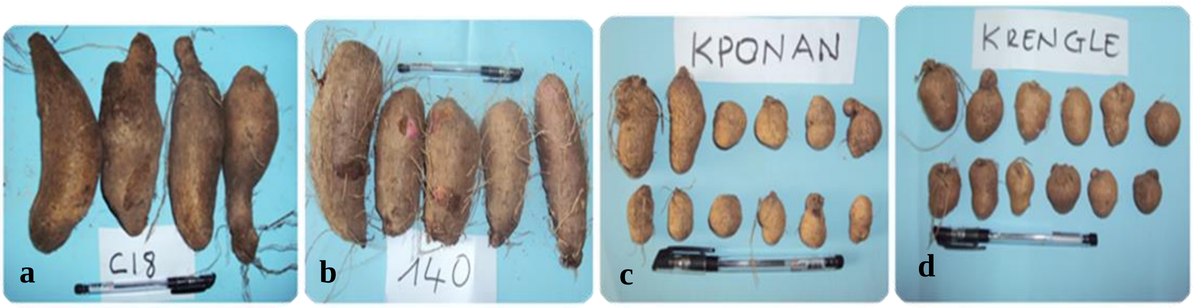

Figure 8: Yams tubers from vine cuttings
a: C18 (123-212 g); b: 140 (82-280 g); c:kponan (3-20 g), d: krenglè (2-21 g)

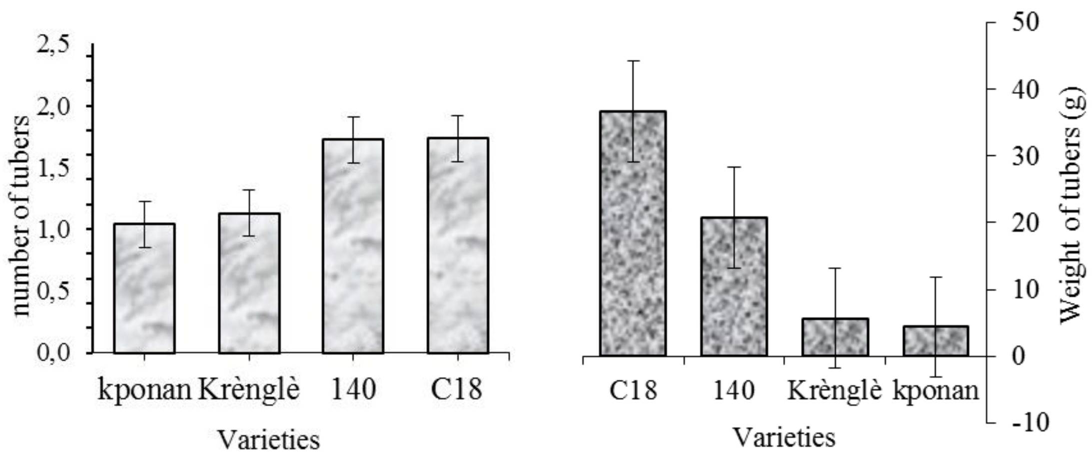

Figure 9 : Effects of varieties on number of tubers produced and weight of tubers of yam vine cuttings.

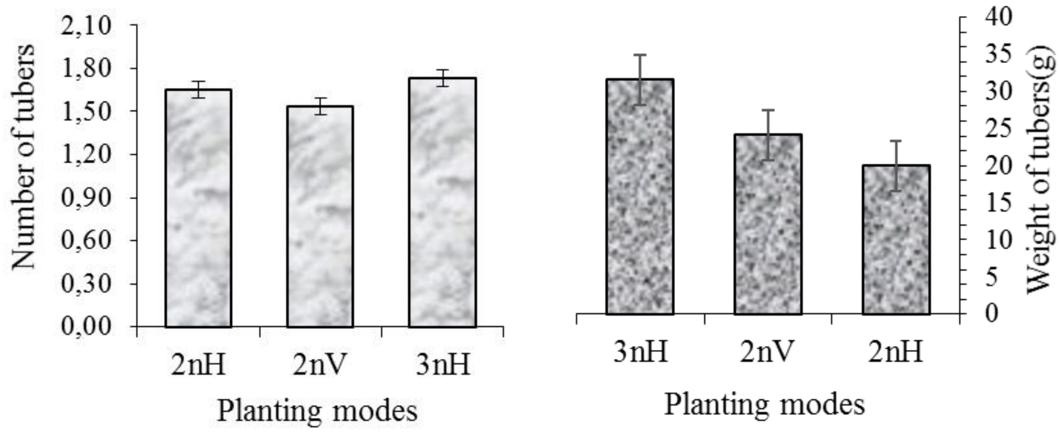

Figure 10 : Effects of planting modes on number of tubers produced and weight of tubers of yam vine cuttings.

Table 2: Effect of planting modes on varieties vine cuttings in term of number and weight of tubers

Varieties	planting modes	number of tubers	weight of tubers(g)
Kponan	2nH	1,16[a]	6,25[ab]
	2nV	0,92[a]	3,00[a]
	3nH	1,03[a]	4,21[ab]
Krenglè	2nH	1,00[b]	5,34[ab]
	2nV	1,15[b]	4,61[ab]
	3nH	1,22[b]	6,48[ab]
C18	2nH	1,72[c]	30,66[b]
	2nV	1,53[c]	28,40[b]
	3nH	1,89[c]	48,39[c]
140	2nH	1,73[d]	12,89[ab]
	2nV	1,63 [d]	24,18[ab]
	3nH	1,63 [d]	24,28[ab]

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test (DMRT).