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Responses of *Typha australis* (Schum. & Thonn.) to a cutting of the stem

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Abstract

Typha australis (Schum. and Thonn.) is an invasive species that has grown considerably in northern Senegal. It is increasingly encountered in the Niayes of intensive farming. Typha causes inconvenience to human and the ecosystem. The control of the species is essentially made by cuttings. The results of which are inconclusive. The aim of this study assesses under experimental conditions the responses of Typha to a cutting of the stem. The plants harvested in the Niayes were transplanted into containers filled with sand of defined characteristics. After an acclimation period, the plants were divided into 2 groups: a control plants and a cut plants applied to 5 terms of 3 repetitions. After cutting, the regeneration is complete. The cut has no effect on Typha. No significant difference was found for the appearance of regrowths beyond the 51st day; the plant height, the diameter, the fresh matters of the aerial parts and AP / UP ratio beyond the 62th day, and the dry matters of the aerial parts and underground parts beyond the 73th day. A single cut does not seem to have any effect on the growth. On the contrary, it stimulates in the long term the species. *Typha australis* develops a strong root system that ensures rapid regeneration. This ability to react to a cutting is partially responsible for its proliferation.

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Introduction

Typha australis (Schum. and Thonn.) invaded the Senegal River delta since the establishment of the Diama anti-salt dam in northern Senegal in the early 80s. It is more and more present in the Niayes, agro – ecological area, which occupies the Atlantic fringe of Dakar to St. Louis on 180 km of coast on a width varying from 5 to 30 km (Fao, 2004). The proliferation of *Typha australis* is possible with two modes of reproduction which can be performed simultaneously: sexual reproduction from the flower by seeds and vegetative multiplication assured by rhizomes.

Typha australis causes water pollution through eutrophication (Amani and Barmo, 2010). It can even damage the structure and the function of some ecosystems which can lead to their inexploitation or to their disappearance (Ndao and Thiam, 2002). Indeed, the vertiginous and disproportionate proliferation of *Typha australis* (Diagne *et al*., 2010) and its resistance cause huge problems to the populations with ecological, socioecomic and sanitary impacts: considerable discomfort in fishing activities in the water plans, land use in market gardening and agricultural use, blocking access to the rivers edge making it difficult agricultural activities, development of home for mosquito larvae thus promoting waterborne diseases such malaria. Thus, *Typha australis* constitutes a real environmental threat for the populations. From then on it seems necessary to ensure the control of the species. This one is essentially made by mechanical way as cuttings.

The work focused on cuts of *Typha australis*, are rare and have not been able to reach significant results; we will mention those of Helsteen *et al.,*(1999), Bimova *et al.,* (2001) and Weston *et al*., (2005). In this study, the effect of cutting the aerial part of plants *Typha australis*, under experimental conditions, is tested. What is the response strategy developed by the species after such disturbances? The answer to this question will clarify the effectiveness or otherwise of a cut.

Materials and methods

Growth conditions

The trial was conducted in Dakar in 30 plastic containers in the shape of cylinders of 30 cm high and 50 cm in diameter, filled with sand dunes whose characteristics are defined (Ndiaye *et al.*, 2012) (Table 1).The containers are irrigated and randomly divided into 2 groups of 5 modalities of 3 repetitions. The water level was kept constant throughout the experiment by additional supply of water.

Typha australis seedlings, having substantially the same age, were collected in the Niayes area by uprooting taking care to preserve the entire rhizome. They were cut at a height of 20 cm and the rhizomes reduced to 10 cm and transplanted into containers. After an acclimatization of 30 days to avoid the stress arising from the uprooting, a second cut was made 20 days after. The plants were randomly divided into 2 groups: control plants and cut plants. The measurements were made from the 51st day after transplantation.

Measurements

Regeneration

The survival of plants and the number of regrowths are determined by counting.

Aerial parts

The aerial parts (AP) were followed by time interval after transplantation to 51st, 62nd, 73rd, 83rd and 92th days after transplantation: the number of the leaves, the height and the stem diameter was measured with a precision caliper of 0.1mm nozzle at the base of the stem.

At harvest each plant of Typha australis is immediately weighed to measure the fresh matter of the aerial parts with a precision balance and then kept in a newspaper. After drying it in an oven for 72 hours at 70 ° C, the dry matter is determined.

Underground parts

The harvest of the underground part (UP) was performed by cutting the container to release the clod. It was then divided into two equal parts: an upper part representing the first 10 cm and a lower part for the last 10 cm. Each part is placed on a mesh screen. The emission of a jet of water collects underground parts (Olsthoorn, 1991; Kane *et al.*, 2004). After drying in an oven at 70 ° C., the dry matters are determined.

Relative growth rate

The relative growth rate (RGR) was calculated over a period of 42 days from the formula of Lorenzen *et al.*, (2001). The total dry matter of the plants was considered. RGR = (lnX2 - lnX1) / (t2-t1) where X1 and X2 represent the mean of the dry matters in the times t1 and t2.

Statistical analysis

The comparison of control plants and cut plants was made from the test of Student. The significance level is 0.05. Data were analyzed by SPSS 20 software (IBM).

Results

Regeneration

The regeneration of Typha australis plants occurs in various forms. 47% of plants were regenerated with regrowths. 20% could not do it but have built regrowths. 33% of regenerated plants have issued one or two regrowths (Fig. 1).

Table 1. Characteristics of soil (Ndiaye *et al*, 2012).

Characteristics	Clay+Silt	Sands	Organic matters	Carbon/Nitrogen	pH
	7,37%	92,63%	0,738%	12,19	7,7

Table 2. Statistic analysis of parameters in the control plants and the cut plants.

Parameters	t	ddl	p
Height	0.915	28	ns
Leaves	2.476	28	*
Diameter	1.481	28	ns
Regrowths	0.958	28	ns
FMAP	0.739	28	ns
DMAP	2.17	28	*
DMUP	0.821	28	ns
DMUPfirst10cm	0.788	28	ns
DMUPlast10cm	0.897	28	ns
AP/UP	3.292	28	*

ns: not significant, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, FMAP: Fresh matters of the aerial parts, DMAP: dry matters of the aerial parts, DMUP: dry matters of underground parts, DMUPfirst10cm: dry matters of underground parts in the first 10 cm, DMUP last 10cm:dry matters of underground parts in the last 10 cm, AP/UP: aerial parts / underground parts.

Height

An increase of the height of the control plants is observed at the 62th day to the 83rd day after transplantation of 72 cm to 118 cm. It is followed by a slight decrease 92nd day when the plants are 96 cm. The height of the cut plants increase between the 51st day and the 62th day of 42 cm to 105 cm (Fig. 2.). At the end of the experiment, the height is 104 cm on average in the 2 treatments that do not show significant differences between them (Table 2). These are however detected at 51st day ($p < 0.001$), the 62th day ($p < 0.05$) and the 83rd day ($p < 0.01$) (Table 3).

Number of leaves

There is an increase of the number of leaves from the 51st to the 83rd day followed by a decrease to 92th day in the 2 treatments with significant differences (Table 2). For control plants, the number of leaves goes from 11 to 17 and to 12 while for those of cut plants increases from 6 to 12 and then reduces to 7 (Fig. 3.). In all the dates, except the 62th day, the production of leaves is higher in control plants with significant differences (Table 3).

Table 3. Statistic analysis of parameters in the control plants and the cut plants during the dates after transplantation.

PARAMETERS	DAT	t	ddl	p
Height	51	8.622	4	***
	62	-6.09	4	*
	73	1.705	4	ns
	83	3.37	4	**
	92	-1.231	4	ns
Leaves	51	8.50	4	***
	62	0.469	4	ns
	73	2.236	4	*
	83	4	4	**
	92	2.683	4	*
Diameter	51	7.778	4	***
	62	4.33	4	**
	73	1.109	4	ns
	83	1.492	4	ns
	92	1.0	4	ns
Regrowths	51	-0.5	4	ns
	62	0.5	4	ns
	73	0.894	4	ns
	83	0.00	4	ns
	92	1.0	4	ns
FMAP	51	7.946	4	***
	62	3.775	4	**
	73	-1.14	4	ns
	83	-0.846	4	ns
	92	1.98	4	ns
DMAP	51	13.214	4	***
	62	8.631	4	***
	73	3.074	4	**
	83	-1.217	4	ns
	92	0.923	4	ns
DMUP	51	9.483	4	***
	62	4.06	4	**
	73	2.288	4	*
	83	0.067	4	ns
	92	0.437	4	ns
DMUPfirst10cm	51	5.692	4	*
	62	2.87	4	**
	73	2.254	4	*
	83	0.213	4	ns
	92	0.593	4	ns
DMUPlast10cm	51	24.426	4	***
	62	5.022	4	**
	73	-0.184	4	ns
	83	-0.989	4	ns
	92	-0.469	4	ns
AP/UP	51	10.615	4	***
	62	3.742	4	**
	73	0.304	4	ns
	83	-1.064	4	ns
	92	0.170	4	ns

ns: not significant, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, FMAP: Fresh matters of the aerial parts, DMAP: dry matters of the aerial parts, DMUP: dry matters of underground parts, DMUPfirst10cm: dry matters of underground parts in the first 10 cm, DMUP last 10cm:dry matters of underground parts in the last 10 cm, AP/UP: aerial parts / underground parts.

Stem diameter

The diameter of the stem of the control plants grows from 1.8 to 3 cm from the 51st to the 92th day after transplantation, whereas in cut plants, it evolves from 1 to 2.9 cm (Fig.4). There is no significant difference between treatments (Table 2). The diameters appear more important in control plants in all dates but from the 62th day, there is no significant difference between the control plants and the cut plants (Table 3).

Table 4. Repartition of the dry matters of underground parts.and DMUP $_{first}$ / DMUP $_{last}$ ratios in the control plants and in the cut plants.

		51	62	73	83	92
Control plants	DMUP first 10 cm	14±1,0	28.63±5.1	30.7±6.4	48.63±10,3	63.2±6.5
	DMUP last 10 cm	4.5±0,32	7.3±0,87	7.3±1.34	7.66±1.18	11.63±0,9
	DMUP first / DMUP last	3.08±0.08	3.99±1.06	4.29±1.14	6.34±0.84	5.45±0.60
Cut plants	DMUP first 10 cm	9.1±1.04	19,91±1,0	21.36±3.1	47.2±5.41	59,83±7.31
	DMUP last 10 cm	0.0±0	4.36±0.51	7.46±0.80	8.63±1.20	12.16±1.70
	DMUP $_{first}$ / DMUP $_{last}$	-	4.6±0.57	2.91±0.71	5.57±1.23	4.93±0.31

DMUP first 10 cm:Dry matter of underground parts in the first 10 cm, DMUP last 10 cm : dry matters of underground parts in the last 10 cm).

Regrowths

The number of regrowths is substantially the same and varies on average between 1 and 1.7 in control plants and between 0.7 and 1.7 for the cut plants (Fig. 5.). Beyond the 51st day, there is no significant difference between the two treatments during the experiment (Table 3).

Table 5. AP (Aerial Parts) / UP (Underground Parts) ratio of the control plants and the cut plants.

	51	62	73	83	92
Control plants	0,39±0,04	0,25±0,06	0,24±0,05	0,19±0,01	0,17±0,02
Cut plants	0,07±0,01	0,10±0,02	0,23±0,01	0,21±0,02	0,17±0,02

Table 6. Relative growth rate (RGR) in the control plants and the cut plants (TDM = total dry matter at times t_1 and t_2

Treatments	TDM t_1	TDM t_2	RGR
Control plants	25.76	88.03	0.029±0.003
Cut plants	9.86	84.36	0.046±0.004

Fresh matters of the aerial parts

The fresh matters increase from 23.3 g to 77.5 g and 4.7 g to 62.1 g respectively in the control plants and the cut plants (Fig. 6.) without significant difference (Table 2). The significant differences are observed at 51st day ($p < 0.001$) and 62th day ($p < 0.01$). Beyond this date, there is no significant difference between Typha plants (Table 3).

Dry matters of aerial parts

The dry matters increase from 7.2 g to 13.2 g and from 0.7 to 12.3 g for the control plants and the cut plants (Fig. 7.) with significant differences between treatments (Table 2). These matters in 51st, 62nd and

73rd days are 10, 3.4 and 1.3 times higher in control plants than in cut plants with respective significant differences for the first 2 dates ($p<0.001$) and for the third date ($p<0.01$). From the 83rd day cut plants are able to produce more, but so many, that control plants without significant differences (Table 3).

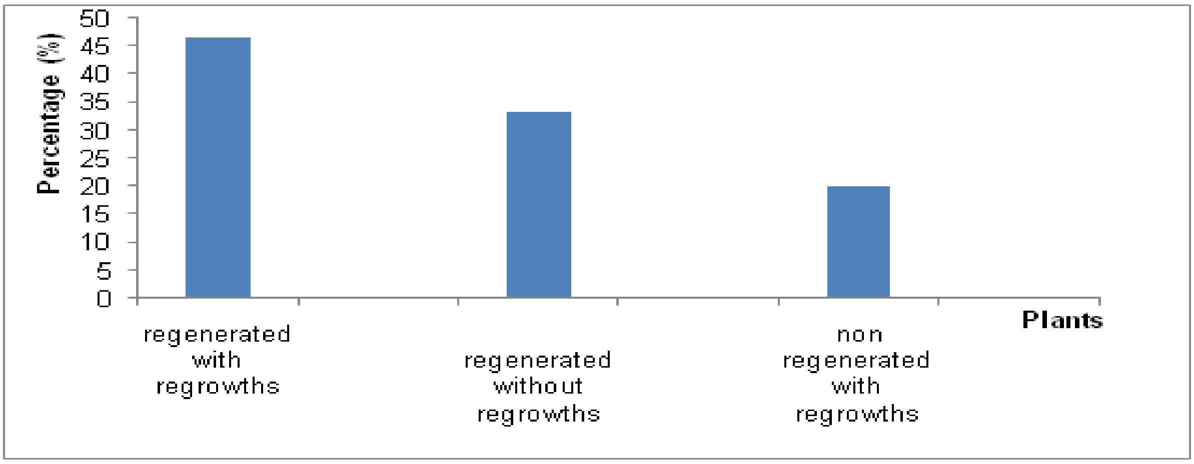

Fig. 1. Percentage of *Typha australis* regenerated or not, with regrowths or without regrowths.

Dry matters of undergrounds parts

The dry matters of the underground parts increase from 18.5 g to 74.83 g and from 9.1 g to 72 g respectively for control plants and for cut plants (Fig. 8.) without significant differences between the 2 treatments (Table 2). Beyond the 73rd, there is no more significant difference between the control plants and the cut plants (Table 3).

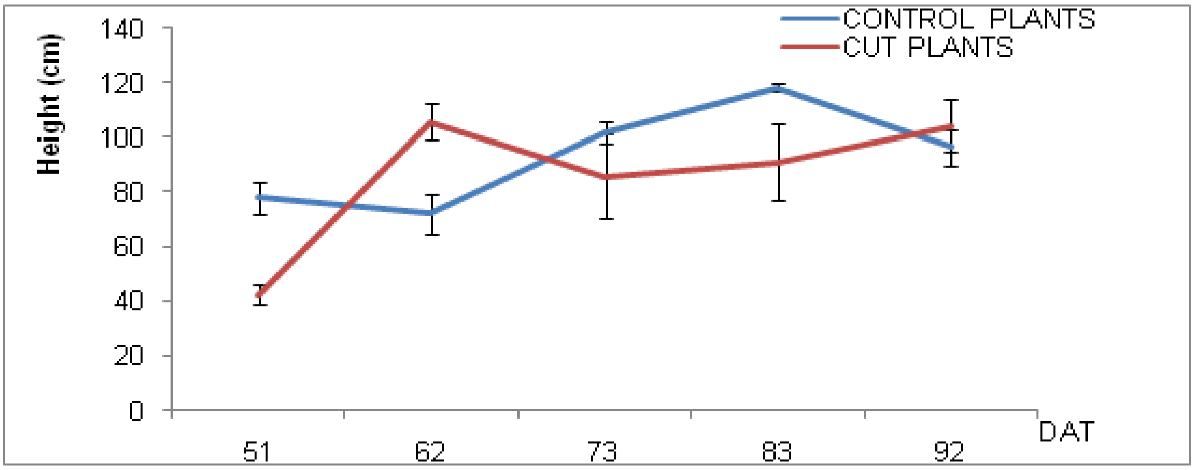

Fig. 2. Evolution of the height of the control plants and the cut plants during the days after transplantation (DAT).

Dry matters of underground parts in the first 10 cm

The dry matters of underground parts in the first 10 cm rise from 14 g to 63.2 g in control plants and from 9.1 g to 59.8 g in the cut plants (Table 4) without significant difference (Table 2). The dry matters in this horizon are more important in control plants with significant differences in 51st day ($p <0.05$) at 62th day ($p <0.01$) and at 73th day ($p <0.05$). Beyond that date, there is no significant difference between treatments (Table 3).

Dry matters of underground parts in the last 10 cm

For the control plants, the dry matters increase from 4.5 g to 11.6 g of the 51st to the 92th day after transplantation. They appear for the cut plants from the 62nd day and they evolve from 4.3 to 12.16 g at the end of the experiment (Table 4). From the 73th day, the dry matters produced in this horizon are more important than those of the control plants. No significant difference was found between the two treatments for this parameter (Table 2). The differences are only recognized at the 51st day ($p < 0.001$) and 62th day ($p < 0.01$) (Table 3).

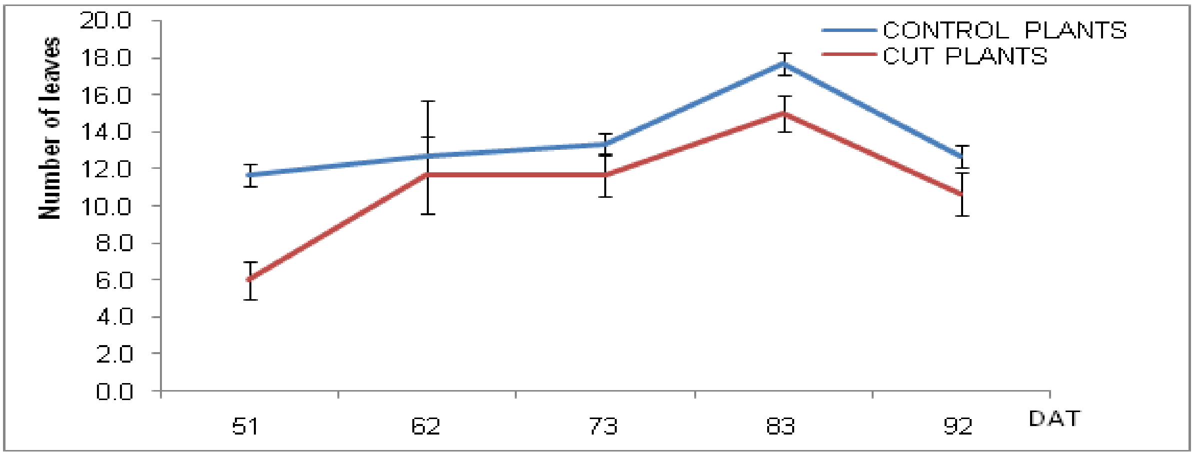

Fig. 3. Evolution of the number of leaves of the control plants and the cut plants during the days after transplantation (DAT).

Repartition of the dry matters of underground parts in the first 10 cm (UP_{first}) and in the last 10 cm (UP_{last})

The dry matters in the first 10cm for the control plants are from 75 to 86% compared to the deep part. The dry matters UP_{first} / UP_{last} ratio tend to increase from 3 to 5 at the end of experiment (Table 4).

For the cut plants, the percentage of the surface portion represents the whole. The rest of the experiment, it is between 48% to 62%. Except the 51st day where the dry matter in the lower part is zero and the 73th day where the report is near 3, the ratio remains close to 5 (Table 4).

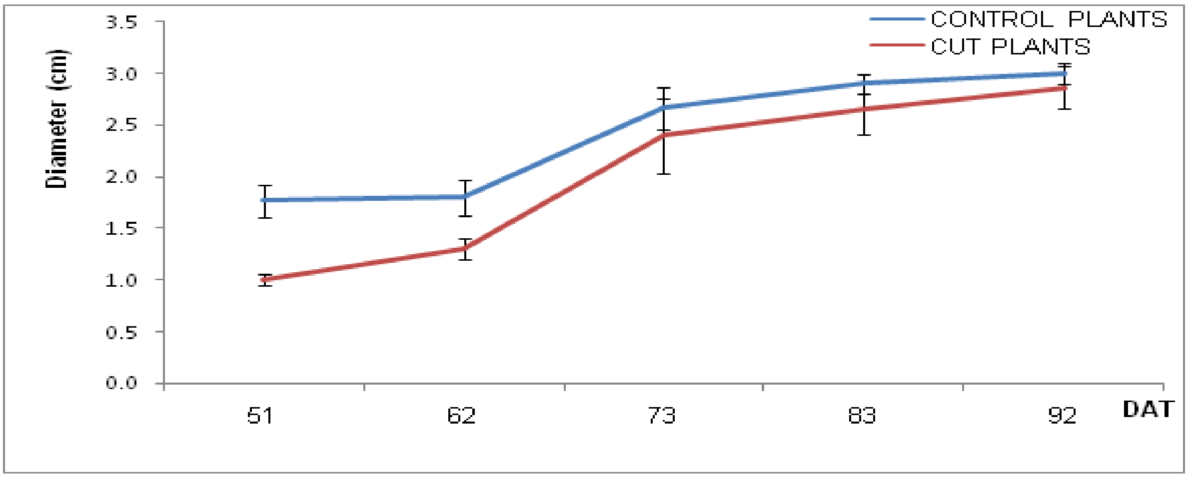

Fig. 4. Evolution of the diameter of the control plants and the cut plants during the days after transplantation (DAT).

Distribution of the total dry matters of the aerial parts and underground parts (AP/UP)

For the control plants, the dry matters of underground parts represent between 77% to 85% and the AP/UP ratio decreases from 0.39 to 0.17 during the experiment. For cut plants, the dry matters of UP represent between 81% and 92% of the total matters. AP/UP ratio increases from the 51st day to the 73th day from 0.07 to 0.23. Then it decreases to 0.17 at 92th day (Table 5). Significant differences were observed for this parameter between treatments ($p < 0.05$) (Table 2).

Relative growth rate

The relative growth rate in both treatments appears higher in cut plants it is 0.04. For the control plants, the rate is 0.029 (Table 6).

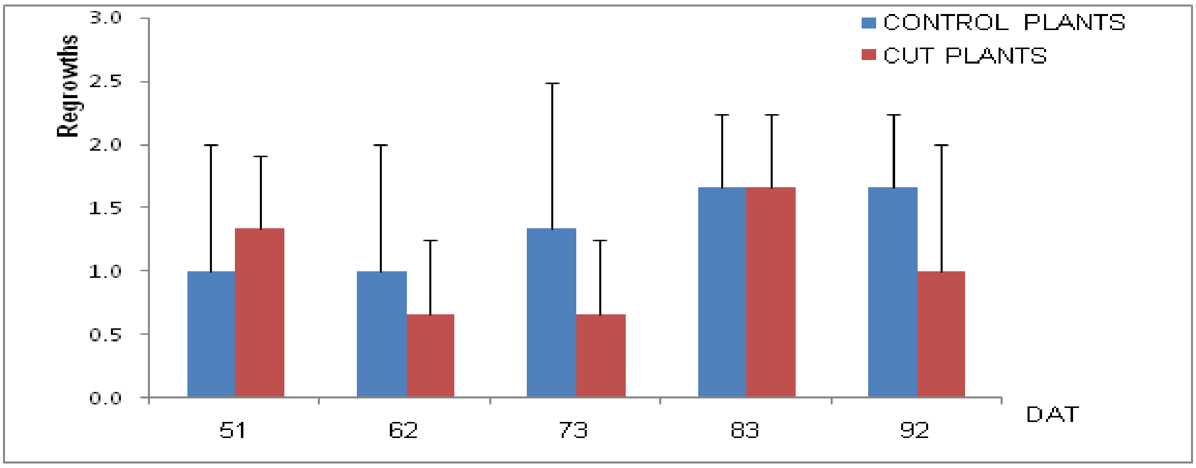

Fig. 5. Number of regrowths of the control plants and the cut plants during the days after transplantation (DAT).

Discussion

The regeneration is total for *Typha australis* after a cut and it is in varying forms. Indeed, the results show that 80% of transplanted plants survived by emitting in some cases regrowths. The 20% lost the initial plant but could build regrowths. It appears therefore that the regeneration potential, from rhizomes, is maximal for *Typha australis*. Riis *et al.*, (2009) in *Myriophyllum spicatum* and *Potamogeton perfoliatus* and Rouifed *et al.*, (2011) in taxa of *Fallopia* find regeneration percentages between 80 and 100%.

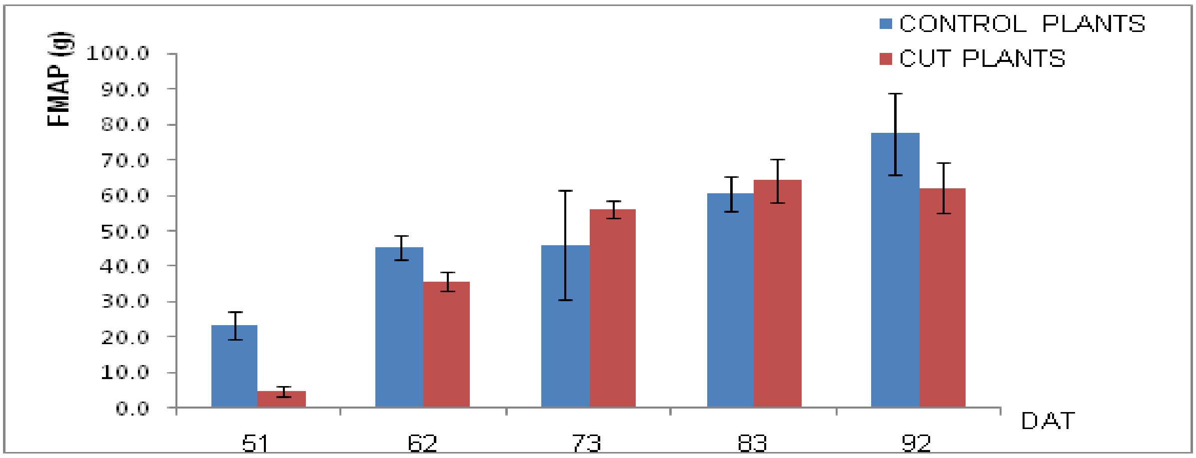

Fig. 6. Fresh matters aerial parts (FMAP) of the control plants and the cut plants during the days after transplantation (DAT).

The cutting effect is not perceptible anymore from the 51st day for the regrowths, from the 62nd day for the number of leaves, the diameter, for the fresh matters of the aerial parts and AP/UP ratio, from the 73th day after transplantation for the dry matters of aerial and underground parts. Beyond these dates, there were no significant differences in these parameters. The responses of the plants in the 2 treatments are the same. *Typha* therefore has a tolerance for a cut.

These results contrast to those of Ziudam and Peteers (2012) who show that the cuttings realized at different levels affect the growth and biomass of *Potamogeton lucens* L. and *P. compressus*. Walters (2006) abounds in the same sense when he realizes cuttings on *Rhizophora mucronata*. In contrast, our results agree with those of Yu *et al.*, (2010) who indicate that after defoliation from 50 to 90% of the plants of *Alternanthera philoxeroides*, subject to flooding, have a mass of dry matters of aerial and underground parts similar to those of controls. This upturn of production was even more important that defoliation was growing.

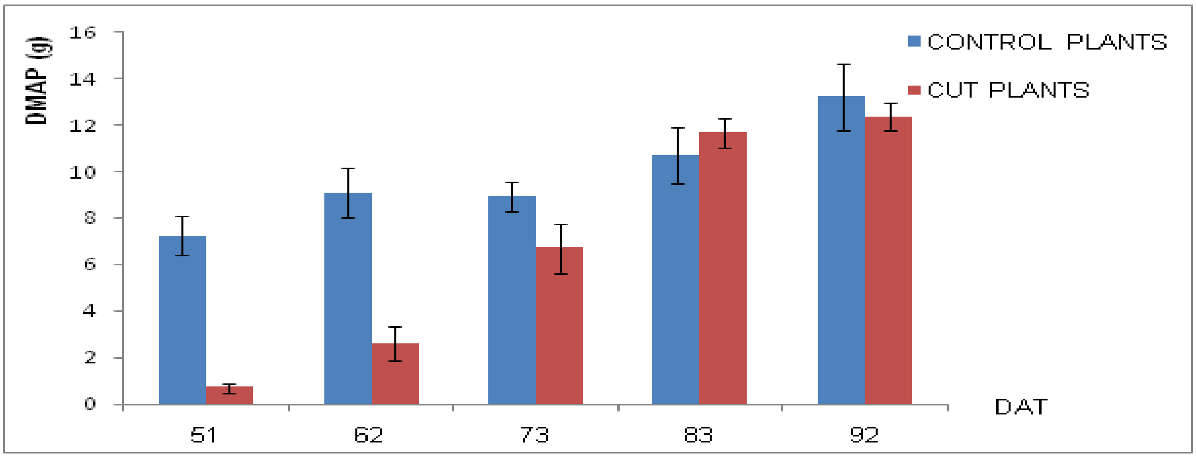

Fig.7. Dry matters of the aerial parts (DMAP) of the control plants and the cut plants during the days after transplantation (DAT).

This increase in aboveground biomass is due to a proliferation of a root biomass which tends to reduce the AP/UP ratio that is the same for the cut plants and the control plants at the end of the experiment. If for the control plants there is an increase of the underground parts, to the detriment of the aerial parts, for the cut plants there is a tendency to develop early in experience the aerial parts at the expense of the underground parts increasing the AP/UP ratio. The trend is reversed from the 83rd day.

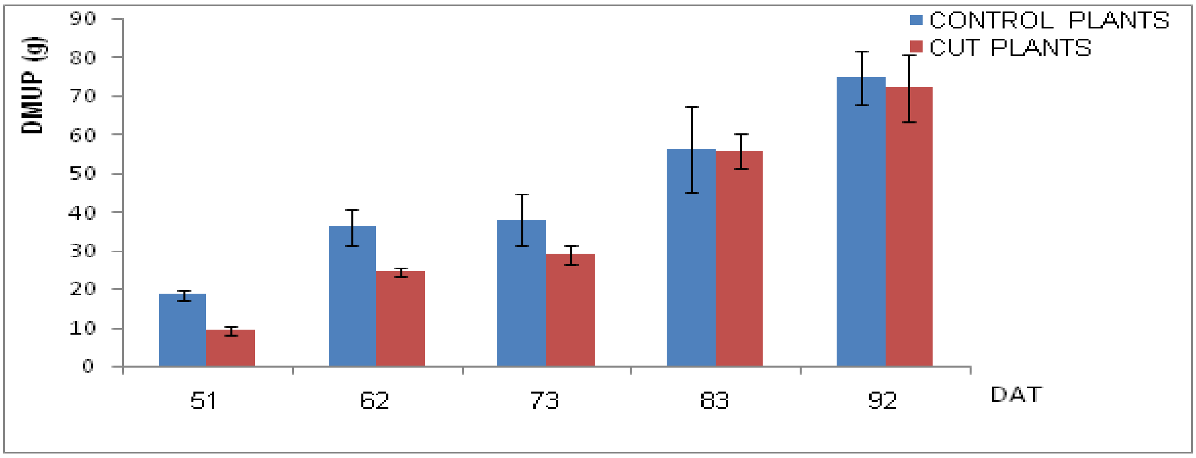

Fig. 8. Dry matters of underground parts (DMUP) of the control plants and the cut plants during the days after transplantation (DAT).

A redistribution of the underground matters occurs: the cut plants tend to preferentially colonize the deep horizons with a relatively homogeneous distribution along the profile so that the control plants develop their root system in the surface horizon before colonizing the deep horizons. The same process was observed in *Fallopia japonica* subjected to the effect of a cut by Rouifed *et al.*, (2011). But this redistribution is accompanied by a decrease in root biomass.

Our results do not show at the end of the experiment a difference in the root mass between the control plants and the cut plants. They contrast of those of Seiger and Merchant (1997).

The relative growth rate is higher in cut plants. The values found of the order of 0.04 are quite similar to those found when the species is placed in immersion (Kane and Akpo, 2015). The cut made had the effect of stimulating growth. Hellsten *et al.*, (1999) achieving cuts on Typha australis at the Lake Guiers show rapid regeneration during a relatively short period. The reserves contained in the rhizome would stimulate more their growth. The accumulation of reserves in the rhizome could play a vital role in the regeneration capacity. Murphy *et al.*, (1990) and Willby *et al.*, (2001) showed that several macrophytes escape the disturbances by developing a strong root system. A single cut, performed on *Typha australis* plants, under our experimental conditions seems to have no effect on the growth of the species. It stimulates in the long-term the species which manages to be also successful as control plants. So this capacity of *Typha australis* to react to a unique cut is partially responsible for the success of its invasive character.

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