First Trials Of Hemp Cultivation For Fiber Applications In The East Of France: Irrigation And Fertilization Analysis

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Abstract : This paper presents results from the first hemp experiments in Aspach-le-bas (France) carried out during summer 2014. Field trials were performed, testing the variety Futura 75 at a seed rate of 50 kg/ha. Two rain densities have been used to analyse the effect of irrigation on its growth. Seven different configurations have been also studied in this work in order to figure out the best one for the hemp cultivation in this region. The composition of hemp biomass in terms of cellulose, hemicellulose and lignine has also been analysed for each configuration.

Key words : industrial hemp, cultivation, cannabis sativa, irrigation, growth, fertilization

Introduction

Industrial hemp is a variety of Cannabis sativa. It has long been cultivated for non-drug use in the production of industrial goods. It can be grown as a fiber, seed, or other dual-purpose crop. It is widely cultivated throughout the temperate climate regions from Europe to North America more than in tropical Asia [1]. In European countries, hemp is cultivated for specialty pulps, cellulose composites, renewable insulation material, and the automotive industry [1-3]. Hemp fibers are used in a wide range of products, including fabrics and textiles, yarns and raw or processed spun fibers, paper, carpeting, home furnishings, construction and insulation materials, auto parts, and composites. Their commercial extraction for textile applications has only been achieved by chemical separation in People's Republic of China, India and some other countries. Other possibilities for refining coarse fibre bundles are the steam explosion process [4, 5], the ultrasonic technique [6, 7] and the enzymatic treatment [8-10] all of them unfortunately not yet industrially viable. The interior stalk (hurd) is used in various applications such as animal bedding, raw material inputs, low-quality papers, and composites. Hemp seed and oil are used in a range of foods and beverages, and can be an alternative food protein source. Oil from the crushed hemp seed is an ingredient in a range of body-care products and also nutritional supplements.

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Hemp seed is also used for industrial oils, cosmetics and personal care, and pharmaceuticals, among other composites. In this work, the main idea is to figure out the best configuration for the cultivation of hemp in Alsace region. For that, in addition to the irrigation effect analysis, 7 different configurations have been studied in order to figure out the best one for hemp cultivation in this region. The composition of the biomass in terms of cellulose, hemicellulose and lignine has also been analysed here. This work represents the first trial of hemp cultivation in this region, thus the results presented here will be useful for future seasons as well as future research on this crop.

1. Materials and methods

Hemp was grown in the area of SADEF, which is located in Aspach-le-bas in Alsace Region (France), as shown in Figure 1. On May 30, 2014 hemp was sown at the density of 50 kg/ha, which is suitable for fiber applications. A surface of 5 ha has been used for this end. Two rain densities (12,5 and 22,5 mm of rain) have been investigated in order to analyse the effect of irrigation on the hemp growth. The seven different configurations, studied here, are summarized in Table 1.

***Table 1** : Tested modalities*

Configuration	Product	N (kg/ ha)	P_2O_5 (kg/ ha)	K_2O (kg/ha)	MgO (kg/ha)	SO_3 (kg/ha)	Mn (g/ha)
T1	/	0	0	0	0	0	0
T2	Ammonitrate 27	50	0	0	0	0	0
T3	Ammonitrate 27	100	0	0	0	0	0
T4	Ammonitrate 27 coated with Mn DDP	100	0	0	0	0	500
	Korn Kali	0	0	140	21	42	0
	Super 45	0	56	0	0	0	0
T5	Orga 6-3-3 (Bio-organic)	100	50	50	0	0	0
T6	Classic 6-2-10+3 (organic-mineral)	100	33	167	50	0	0
T7	Orga 6-3-3 (Bio-organic)	100	50	50	0	0	0
	Compost Φ> 20 mm	15. 10^3					
	Compost Φ< 20 mm	15. 10^3					

***Figure 1:** hemp cultivation location (from google map)*

2. Results and discussions

2.1 Irrigation analysis

In order to analyse the effect of irrigation on the hemp growth, two rain densities (12,5 and 22,5 mm of rain) have been investigated. However, because of the quantities of rain in summer 2014 espacially in july 2014 (Appendix), we have irrigated only two times on june 20 and 26, 2014. Figure 2 shows a significative difference between irrigated and non irrigated zones in terms of color as well as yield. The hemp growth was too much better in the case of irrigated zones.

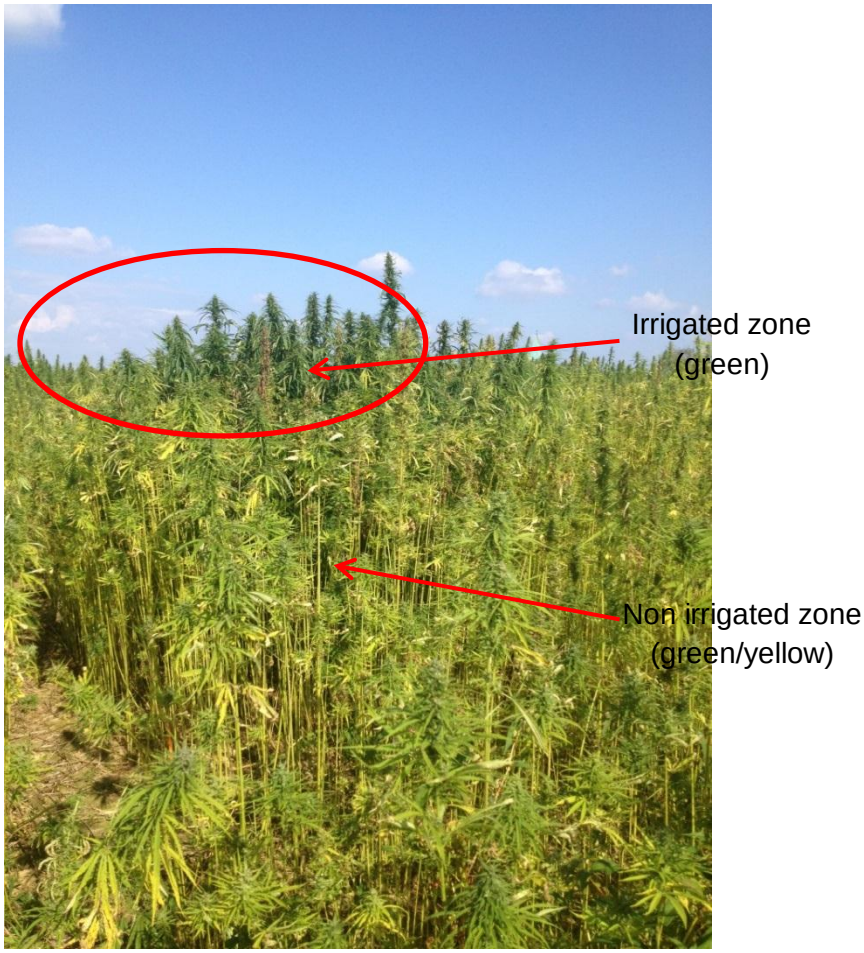

Figure 2 : *Irrigation impact (photo of Dr Lotfi Harrabi)*

2.2 Yield analysis

Generally, we can say that we had a good season in terms of yield, we also observed a good uniformity in the biomass height which reached 3,5 m (Figure 3).

Figure 3 : *Photos of the hemp cultivation trials in Aspach-le-Bas – season 2014 (photos of Dr Lotfi Harrabi)*

The yield results corresponding to the different modalities are presented in Figure 4. They vary from 4,6 to 10,9 tons/ha. Figure 3 shows that there is no big difference between the two rain densities analysed here in terms of yield. However, we can point out that the yield has almost doubled for the trial without fertilizer (T1 modality). The irrigation allowed the plant to grow more, probably at the root level, allowing it to search for the nutrients it needs alone. This result is very interesting because even if the rest of summer was very rainy, the irrigation impact was very important. Thus, it seems that a low water supply (rain or watering), but at the right time, is important for the hemp cultivation in the local conditions. The other modalities, except T3, did not have this benefit related to the water supply because they had the mineral elements available by the fertilizers (T2-T7). We can note that the T4 modality (complete fertilization) has the best yield (10,7 tons / ha). The other modalities (T5; T6 and T7) have also good yields (9 - 10 tons/ha). By comparing the effect of organic and mineral fertilizers, we found that the T4 modality (complete fertilization with minerals), despite its better yield, presents a greater risk of pollution than the T5 modality (complete fertilization with organic materials). Indeed, mineral fertilizers are very solvent and present a risk of leaching pollution of Nitrates. While organic fertilizers are less solvent, they present less risk of pollution especially as yields remain close to each other. Hence it is interesting to choose the suitable organic fertilizers for the hemp cultivation.

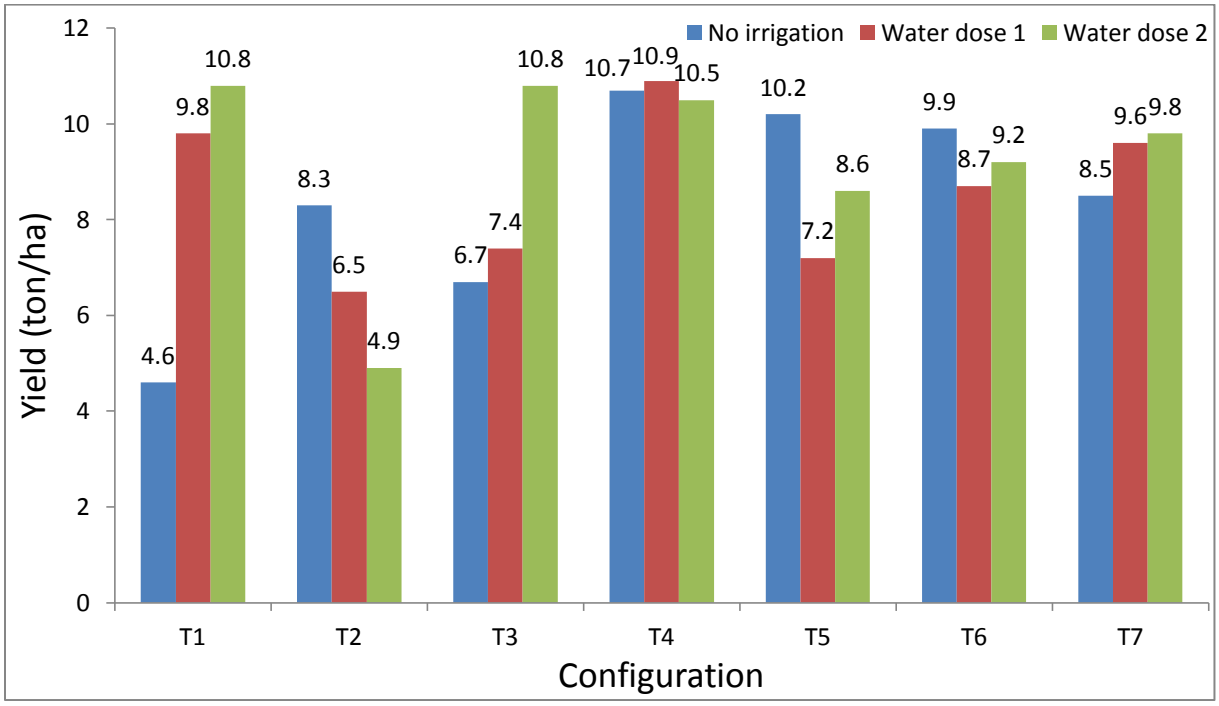

Figure 4 : *yield corresponding to different modalities*

The round bales obtained after the harvest (Figure 5) are then sent to EUROCHANVRE for decortication and further fiber degumming process.

Figure 5 : *hemp round bales (photo of Dr Lotfi Harrabi)*

2.3 Biomass composition analysis

For each modality, we have analysed the biomass composition. The tests were performed on hemp stem. The results obtained are summarized in Figure 6. In our calculations, only the cellulosic (cellulose and hemicellulose) and lignin components were taken into account. The other components (mineral matter, soil fraction, water) were also measured but not presented here. The test results analysis shows that the T1 modality (without fertilization) has more cellulose than the other modalities (76.2%) and a very low percentage of lignin compared to the other modalities (12.7%). This is a very interesting result because no fertilization is required to have more cellulose and less lignin in the hemp biomass. This is hopefully what is desired for fiber and textile applications. We also obtained similar results with T5 modality (organic fertilization 6-3-3) with 74% cellulose and 12.6% lignin.

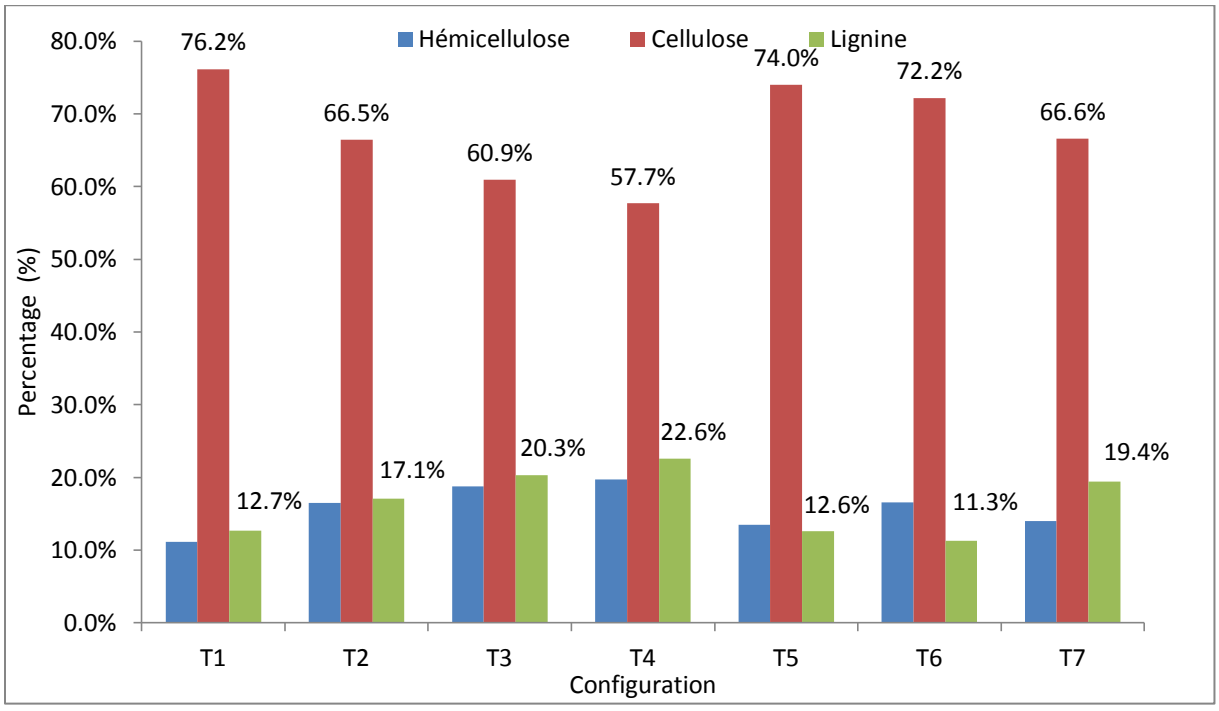

Figure 6 : *Biomass composition for each modality*

Conclusion

In this project, Hemp cultivation was studied for the first time in Aspach-le-bas in France. the results found here will be very useful for future seasons. Thus, this study allowed us to evaluate the nutritional needs of the hemp plant in terms of water consumption and fertilization. The configuration T_1 (without fertilization) was very interesting for us in terms of yield and composition. In fact, after only 2 irrigations, this modality got a very good yield (10,8 tons / ha) and a very high fraction of cellulose compared to the other modalities (76,2%), which is very interesting for fiber applications. This water input probably allowed the plant to search for the nutrients it needs alone.

Acknowledgment

This research has been supported by the Water Agency Rhin-Meuse in France. The authors would like to thank all the members of CHAFILTEX consortium for their support.

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Appendix

Table 2 : *Weather conditions in Aspach-le-Bas – Summer 2014*

May		June		July		August	
Day	**Rain (mm)**	**Day**	**Rain (mm)**	**Day**	**Rain (mm)**	**Day**	**Rain (mm)**
5/01/14	12	6/01/14	1	7/01/14	0	8/01/14	0
5/02/14	3	6/02/14	0	7/02/14	0	8/02/14	2,5
5/03/14	0	6/03/14	0	7/03/14	0	8/03/14	0
5/04/14	0	6/04/14	8,5	7/04/14	7,5	8/04/14	1,5
5/05/14	0	6/05/14	0	7/05/14	0	8/05/14	0
5/06/14	5,5	6/06/14	0	7/06/14	9	8/06/14	0
5/07/14	8	6/07/14	0	7/07/14	0	8/07/14	5
5/08/14	3	6/08/14	0	7/08/14	14	8/08/14	10
5/09/14	4,5	6/09/14	0	7/09/14	2	8/09/14	6
5/10/14	2	6/10/14	0	7/10/14	6	8/10/14	5
5/11/14	5	6/11/14	0	7/11/14	7	8/11/14	0
5/12/14	2	6/12/14	0	7/12/14	7	8/12/14	0
5/13/14	0,5	6/13/14	0	7/13/14	11	8/13/14	22
5/14/14	5	6/14/14	0	7/14/14	0,5	8/14/14	5,5
5/15/14	0	6/15/14	0	7/15/14	0	8/15/14	7
5/16/14	0	6/16/14	0	7/16/14	0	8/16/14	0
5/17/14	0	6/17/14	0	7/17/14	0	8/17/14	0
5/18/14	0	6/18/14	0	7/18/14	0	8/18/14	0
5/19/14	0	6/19/14	0	7/19/14	2	8/19/14	0
5/20/14	0	6/20/14	0	7/20/14	15	8/20/14	0
5/21/14	17	6/21/14	0	7/21/14	6	8/21/14	0
5/22/14	0	6/22/14	0	7/22/14	24	8/22/14	0
5/23/14	1,5	6/23/14	5	7/23/14	0	8/23/14	3,5
5/24/14	0	6/24/14	0	7/24/14	0	8/24/14	0
5/25/14	10	6/25/14	0	7/25/14	10	8/25/14	9
5/26/14	1	6/26/14	0	7/26/14	0	8/26/14	9
5/27/14	0	6/27/14	0	7/27/14	0,5	8/27/14	0
5/28/14	0	6/28/14	18	7/28/14	5	8/28/14	1,5
5/29/14	0	6/29/14	1	7/29/14	10	8/29/14	0
5/30/14	0	6/30/14	0	7/30/14	7	8/30/14	0,4
5/31/14	0			7/31/14	0	8/31/14	0,5
Mean :	**80**	**Mean :**	**33,5**	**Mean :**	**143,5**	**Mean :**	**88,4**