Forensic Science International 220 (2012) 265–270

Contents lists available at SciVerse ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Yield and turnover of illicit indoor cannabis (*Cannabis* spp.) plantations in Belgium

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ARTICLE INFO

Article history:
Received 31 October 2011
Received in revised form 12 March 2012
Accepted 14 March 2012
Available online 13 April 2012

Keywords:
Cannabis sativa
Yield
Profits
Price-setting
Snowball sampling

ABSTRACT

In prosecution, Belgian judiciary currently uses outdated yield figures (28.1 g per plant, sold at € 3/g at grower level) for fining illicit indoor cannabis plantations. Using state-of-the-art cultivation techniques, our growth experiments showed that yield is better expressed in g/m^2 cultivated surface area rather than in g per plant, and that yield varies significantly between different cannabis strains. It was found that the lower-bound of the one-sided 95% confidence interval of the yield of an indoor cannabis plantation can be set at 575 g/m^2. Prices and pricing mechanisms were investigated using interviews with respondents selected through snowball sampling. Results reveal that (i) the Belgian cannabis market chain is highly complex; (ii) unit prices are predominantly determined by transaction sizes; but also (iii) a set of product- and socially-related price-fixing mechanisms have an equally important role. At grower level, respondents reported prices for 1 g of dry cannabis buds to range € 3.00–4.25.

1. Introduction

Due to involvement of criminal organisations in the cannabis market chain, drug policies in the Netherlands since 1995 put increased pressure on coffeeshops, and stepped up criminal investigation and subsequent legal proceedings [1]. As a result, cannabis cultivation shifted towards Belgium where criminal investigation on illicit cannabis cultivation was less-advanced [2–4]. The latter is reflected in the rise in number of seizures in Belgium: in 2003, only 35 cannabis plantations (*Cannabis* spp.) were seized by the police. By 2007, this number had risen to 466 and by 2010 to 979. Half of seized plantations consisted of more than 50 plants, meaning that they were run on a scale that exceeds production for own use. In the period 2007–2010, increase in seizure is reported for all plantation sizes (Fig. 1). Although these figures are partly explained by increased interest in and investigation of illicit cannabis growing by the Belgian police, indoor cannabis growing in Belgium is undeniably on the rise.

Judicial response to these activities consists of seizure (and subsequent confiscation) of the profits gained by the perpetrators. Due to the current lack of hard facts, Belgian judiciary is forced to make rough estimations of the profits gained, based on estimates of crop yield of seized cannabis plantations and wholesaler prices used in – amongst others – Dutch coffeeshops. Today, the Belgian judiciary uses a crop yield estimation made by the University of Wageningen, The Netherlands [5] and set at 28.1 g of dry female flower buds per plant (lower bound of the one-sided 95% confidence interval). For subsequent estimation of financial profits, the Belgian police currently relies on data obtained from internet sites, the Dutch police and Belgian judicial files. On the latter basis the price used by commercial cannabis growers is arbitrarily set at € 3/g cleaned and dried cannabis buds. The Belgian police further assumes, on the basis of grey literature resources, that one grow cycle of indoor cannabis can be completed in 11 weeks [6]. Observations made by Belgian police at confiscation of indoor cannabis plantations during the past few years nevertheless suggest that illicit growers nowadays achieve plant yields that are much higher than 28.1 g per plant. Based on grey literature resources, internet blogs and judicial files, police furthermore assumes that the currently used price criterion of € 3/g at growers' level needs to be raised.

The study results of Toonen et al. [5] were based on discovery and confiscation of 77 indoor cannabis plantations for which yield was estimated at the spot. Since upon discovery, police has usually little clues on the precise nature of varieties used by growers, Toonen et al. [5] could not account for variability in yield between different so-called cannabis strains. Vanhove et al. [7] showed that the variety used is a main yield-determining factor in indoor cannabis production. The latter authors used state-of-the art growing techniques (i.e. using high-power assimilation lamps, atmospheric control through turbines with carbon filters and a standardized fertilization scheme) to reveal most relevant yield

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doi:10.1016/j.forsciint.2012.03.013

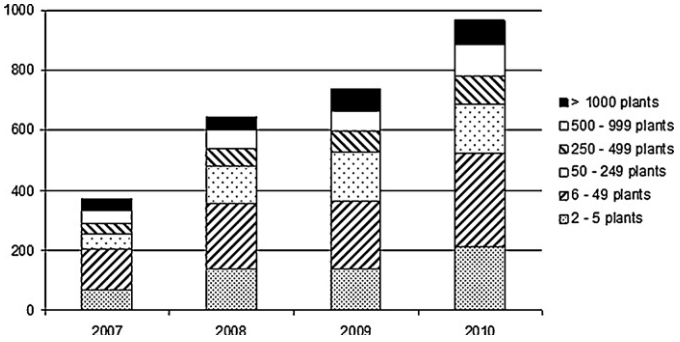

Fig. 1. Number of confiscated illicit cannabis plantations of 6 different scales in Belgium (2007–2010) (unpublished data from the Belgian Federal Police).

determining factors, but nevertheless failed to obtain yield figures that concur with recent police observations.

This paper has following objectives: to (i) optimize indoor cannabis cultivation as described by Vanhove et al. [7] with the aim to propose a realistic and scientifically sound yield figure of present-day indoor cannabis cultivation and (ii) describe price-fixing mechanisms in the current cannabis value chain, aiming at an updated and legally acceptable unit price for ready-to-use cannabis at the level of the grower.

2. Materials and methods

2.1. Indoor cannabis crop yield

Growth experiments are built on the research methodology developed by Vanhove et al. [7]. Experiments were performed in the same grow room under similar environmental conditions as described in the latter paper. In this section, materials and methods will be presented in detail when and where they differ from those used by Vanhove et al. [7].

2.1.1. Experimental design

Since Vanhove et al. [7] showed that yield under overhead lights of 600 W is significantly higher than yield under 400 W lamps, and since the Belgian Federal Police claims the vast majority of indoor cannabis plantations in Belgium exclusively uses 600 W lamps (Benny Van Camp, Judicial Commissioner of the Directorate of Crime against Persons, personal communication), grow experiments were performed only using 600 W lamps. Federal Police further commented on the grow experiment by Vanhove et al. [7] by stating that plant densities as high as 20 plants/m^2 are rarely encountered. The present study therefore used and compared more realistic plant densities of 12 and 16 plants/m^2. Toonen et al. [5] studied 77 confiscated indoor cannabis plantations in the Netherlands and showed that 30 (39%) had plant densities in the range of 9–16 plants/m^2, whereas only 20 plantations (26%) had plant densities in the range of 17–24 plants/m^2 and only 12 (16%) plantations had plant densities in the range of 25–32 plants/m^2. The latter results confirm that densities of 12 and 16 plants/m^2, used in the present study, cover a realistic plant density range. The experiment consisted of a full factorial design with two repetitions of combinations of two factors: (i) 2 plant densities (12 and 16 plants/m^2) and (ii) 4 cannabis varieties. Varieties and plant densities were combined in blocks of 1 m^2, each containing 12 or 16 plants, depending on the plant density factor applied. The 8 factor combinations thus obtained were set up as two big blocks of 4 m^2 with equal plant densities, each containing 4 sub-blocks with different varieties. All 8 sub-blocks were repeated in adjacent blocks with big blocks positioned crosswise and with varieties placed so that the complete design formed a Latin square (Fig. 2).

16/m² BB	16/m² SK	12/m² SH	12/m² XX
16/m² XX	16/m² SH	12/m² SK	12/m² BB
12/m² SK	12/m² BB	16/m² XX	16/m² SH
12/m² SH	12/m² XX	16/m² BB	16/m² SK

Fig. 2. Experimental design of cannabis cultivation experiments (BB: Big Bud; SK: Skunk #1; SH: Silver Haze #9; XX: unknown variety).

2.1.2. Varieties

The growth experiment used four varieties (also called strains); i.e. Skunk #1, Silver Haze #9, Big Bud and an unknown variety X. Skunk #1 and Silver Haze #9 were propagated by cuttings from seedlings that were produced from feminized seeds which were purchased on July 8, 2010 from the Sensi Seed Bank (Amsterdam, The Netherlands). Propagation procedure was equal to the protocol used by Vanhove et al. [7]. Variety Big Bud was propagated by cuttings from parent plants that were retained in the study of Vanhove et al. [7]. It was used in the present study, because the latter authors found highest mean yield (335.78 ± 205.63 g/m^2) with this variety (together with plants from variety Super Skunk). Including the Big Bud variety in the present study allows for benchmarking yield figures with results obtained by Vanhove et al. [7]. The unknown variety X was obtained from 10 uniform cuttings (rooted in rock wool cutting blocks, plant height between 20 and 30 cm) that police confiscated in early July 2010 at a typical Belgian indoor cannabis plantation. It was used as a realistic control in the present study. Cuttings from variety X were cultivated to mother plants that were subsequently propagated following methods presented by Vanhove et al. [7].

2.1.3. Cultivation

The grow cycle started on 14 February 2011 with potting of rooted cuttings and finished with harvest on 29 April 2011 (week 11). Rooted cuttings were placed in square pots of 11 L (sides of 0.25 m; height: 0.21 m) and positioned in 4 rows of 4 pots (yielding blocks with 16 plants/m^2) or in 4 perpendicular rows of 3 pots (yielding blocks with 12 plants/m^2). Philips® Master SON-T PIA Plus E40 high pressure lamps of 600 W were positioned above the centre of each block of 1 m^2. Pots were filled with peat soil (pH 6.4, OM: 20%) that was mixed with 5% perlite, following Green [8]. Nutrition was applied according to the *Canna Terra* grow scheme (http://www.onlinegrowsupplies.com/CANNA_Terra_kweekschema.pdf) (Table 1). For details on fertilizers and additives used, we refer to Vanhove et al. [7]. Grow cycle consisted of a vegetative stage of 2 weeks (18 h of light per day) and a flowering stage of 9 weeks (with 12 h of light per day). Environmental control measures were similar to those used by Vanhove et al. [7]. However, some adjustments were made to optimize temperature control in the grow room. Green [8] and Adams [9] claim that the optimum temperature in a cannabis grow room ranges 20–25 °C. Since growth experiments were performed in winter when

Table 1
Scheme applied in the cannabis grow experiments, based on the Canna® Terra grow scheme.

Week	Light (h/day)	Terra Vega (mL/10 L)	Terra Flores (mL/10 L)	Rhizotonic (mL/10 L)	Cannazym (mL/10 L)	Cannaboost (mL/10 L)	PK 13/14* (mL/10 L)
7–8	18	20	–	40	–	–	–
9	12	40	–	15	25	–	–
10–11	12	–	60	5	25	30	–
12	12	–	55	5	25	30	15
13–16	12	–	60	5	25	30	–
17	12	–	–	–	25	30	–

All products are seized Canna® products, obtained from the Belgian Federal Police. Weeks are calendar weeks.