

## Annex 2 - Estimating yield

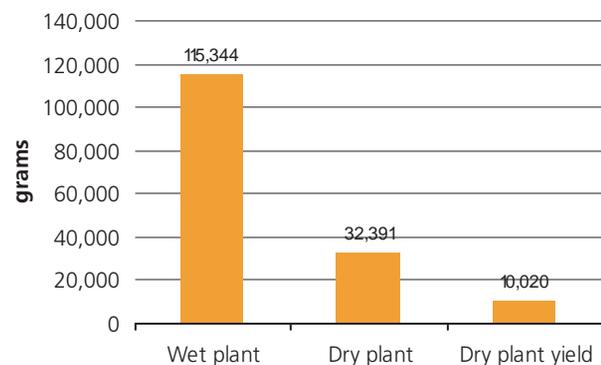
Various figures are used by law enforcement to estimate the amount of cannabis that could be produced on a given area of land, but the scientific basis of these estimates is often unclear. A number of factors need to be taken into consideration:

- Land dedicated to cannabis resin production will only yield about 4 per cent as much drug product by weight as will a similar sized field dedicated to herbal cannabis.
- Sinsemilla yields may differ from commercial yields, which allow for a lot more bulk material to be included in the product.
- For commercial yields, it is important to distinguish between the product as sold and the product used, the weights of which may be very different.
- Cultivation conditions, particularly the availability of water, can play a major role.
- The experience of the grower and the style of cultivation are key.
- If the climate is such that multiple crops are possible, this must be tallied, taking possible variation between seasonal outputs into consideration.
- If the land is situated indoors, a different set of rules applies.

Processing herbal cannabis from a whole plant in the field to saleable product requires drying the material and cutting away the parts not deemed suitable for sale. Drying results in a substantial loss of weight, with the dry plant weighing about 70 per cent less than the wet plant. After trimming, the wet plant to dry product ratio is said to be about 14 per cent.<sup>251</sup>

Empirically-based yield figures for sinsemilla can be drawn from the medical cannabis industry, where a scientific approach is taken to produce maximal yields of good quality under controlled indoor conditions with minimised input costs. The *Bureau voor Medicinale Cannabis* in the Netherlands is one such facility. Analysis of a recent crop would suggest that saleable material represents about 30 per cent of dried plant weight and about 8 per cent-10 per cent of wet plant weight. This is easily summarized in the ratio 10-3-1.

**Fig. 15: Ratio of wet plant to dry plant to yield in a test crop of medical cannabis**



Source: Bureau voor Medicinale Cannabis, Netherlands.

Given the expertise of the medical producers, these figures should thus be regarded as optimal sinsemilla yields. However, street product will likely contain more plant bulk – this is obvious in the case of non-sinsemilla products, because seeds are the densest part of the plant. Medical cannabis producers, concerned about fungal and mould growth, also tend to dry their product more than illicit producers, typically to about 10 per cent moisture content. Street samples generally contain more moisture, ranging from 12 per cent-16 per cent, but the impact on total bulk is minimal.<sup>252</sup> In the end, the 10-3-1 ratio (wet weight of plant – dry weight of plant – dry weight of product) is probably reasonable for sinsemilla.

For low-grade cannabis, most of the seeds (and perhaps more stems and leaves) are included. Inert, or relatively inert, portions are generally removed before smoking.<sup>253</sup> Seeds make up 23 per cent of the dry weight of the entire plant, and stems 43 per cent.<sup>254</sup> Most of the stem weight is not included in the street product, but most of the seeds are. Even if all of the stem were removed, seeds would still make up about 40 per cent of the dry product by weight. Allowing for some stem, it is possible that about half the weight of low-grade cannabis, as sold on the streets, is unusable.

Yields per plant and unit area are dependent on the degree of care given to the crop and the style of cultiva-

tion. Today, there are a wide variety of cultivation styles in evidence around the world. In many developing countries, people simply drop seeds and return months later to collect whatever develops, a practice that is virtually cost-free and thus very difficult to deter. In others, huge plantations of cannabis are cultivated. The threat of asset forfeiture has led cultivators in developed countries to plant on public lands ('guerrilla grows'). In still others, law enforcement pressures or an unsuitable climate have pushed production indoors, where inputs are higher but so are returns.

Within these styles, there is further variation. Some cultivation techniques emphasise dense plantings, while others focus on a smaller number of highly productive plants. It has been argued that, for the average home garden plot, cultivating a large number of small plants or a small number of large plants results in roughly the same yield.<sup>255</sup> Many indoor growers discuss their yields in terms of wattage – one pound per 600-watt high-pressure sodium bulb being a common rule of thumb. But this is not much help in comparing indoor and outdoor yields. The following discussion concludes that yields should be expressed per unit area (square metre or hectare) rather than per plant.

A single cannabis plant, given individual attention and wide room to grow, can be far more productive than the average plant cultivated in the dense conditions that typically accompany clandestine grows. Further, low planting densities quickly reach the point of diminishing returns for growers.<sup>256</sup> Using low-density, per-plant yields as a rule of thumb is likely to produce inflated estimates, and that laws that seek to regulate the number of plants grown, rather than the land area under cultivation, may be misplaced.

In practice, many traditional growers use much greater planting densities, especially on prime lands. In Morocco, to cite an extreme case, about 30 plants are cultivated per square metre in irrigated areas.<sup>257</sup> Similar densities are used in 'sea of green' indoor operations, where per-plant yields are in the neighbourhood of 10 g apiece,<sup>258</sup> far from the 'pound a plant' rule sometimes cited.<sup>259</sup>

In addition to plant density, cultivation style is clearly relevant in determining yield. Dense, indoor, high-tech plantings are more productive than dense, outdoor, traditional ones. Looking at some 35 yield estimates given by a wide range of different sources, a degree of consensus is discernable on the yields per square metre of the various cultivation strategies. Looking first at the

outdoor situation, yields vary from as low as 47 grams per square metre for varieties grown without irrigation in difficult climates, to as high as 500 grams per square metre in well-tended gardens. An average of about 200 g per square metre outdoors has been said to be consistent with figures gathered in US court cases,<sup>260</sup> but conditions in the United States are generally better than those encountered in much of the developing world. For the purposes of the present analysis, a figure of 100 grams per square metre (or one metric ton per hectare) will be used for outdoor crops when cultivation style is unspecified.

All this highlights that cannabis is an extremely productive drug crop. One square metre of outdoor cultivation space is sufficient to supply a user with one 0.27 g joint a day (a reasonable size for a European user) for a year. A hectare could produce enough cannabis to supply 10,000 daily users. If all 162 million annual users smoked this amount (which is clearly not the case), global demand could be met by a production area of 162 square kilometres, an area about the size of Liechtenstein.

There is one important complicating factor, however. Some parts of the world appear to harvest multiple cannabis crops, and there is considerable confusion about this matter. In latitudes where there is variation in the seasons, there is usually one prime season (corresponding to the summer months) and up to three subsidiary seasons. In Lesotho, for example, it is often claimed that there are two or three harvests, but one of these may simply be the weeding of the male plants. Yield figures for off-season crops would be lower in all but the most generous climates, and some farmers may only deem the summer crop to be worth the effort. Thus, figures on the area under cultivation may vary seasonally for each area under consideration, and the yields per unit area would also vary by season. This considerably complicates yield estimates based on cultivation area.

In addition, it is nearly impossible to say how much cannabis is produced indoors in developed countries. According to a wide range of sources, indoor yields vary from a low of just over 300 grams to a high of just under 800 grams a square metre. These yields are produced by a number of different strategies, with considerable debate as to which is most productive. Individual plants can be freakishly productive, and this can be perpetuated, to some extent, by cloning. Overall, an average of about 500 grams per square metre per harvest seems to be confirmed by several sources. Some medical

providers cite much lower figures, however. Of course, the real productivity of indoor 'plots' is determined by the number of crops that can be produced in a year. As discussed above, a four-stage cultivation system allows three to six crops per unit of floor area per year. Thus, indoor crops are between 15 and 30 times as productive per square metre of cultivation space than are outdoor crops.

But indoor-grown cannabis, generally being sinsemilla of good seed stock, is also more potent than most outdoor-grown product. In the Netherlands, a strong correlation has been found between potency and price.<sup>261</sup> Data from the United States suggest that sinsemilla is worth three to 12 times as much as commercial grade cannabis per ounce.<sup>262</sup> This suggests that, in addition to producing greater bulk, indoor production is likely to produce much greater value. While input costs are also greater, there would appear to be a great deal of incentive to produce indoors in consumer countries, avoiding the hazard of cross-border trafficking, particularly in a climate of enhanced law enforcement.

The share of the market commanded by indoor, high-potency production is the subject of ongoing investigation. This is a key area of research, as it has implications for both enforcement and public health. But since the bulk of the global market seems to be supplied by traditional outdoor grows, a global production estimate can ignore this variable without hazarding too much error.