Traditional Crop Revised: Yield and Quality of Palm-Tree Kale, Grown as a Mechanised Industrial Crop, as a Function of Cutting Height

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Abstract

Palm-tree kale is a local crop grown in some areas of the northern Apennines, Italy. The food industry is presently interested in recovering traditional recipes: besides the processing aspects, a critical factor for raw-material production is complete automation. Previous research demonstrated the possibility of growing palm-tree kale at high density, with early simultaneous harvest. Biomass partitioning and quality as a function of cutting height were further investigated. An autumn crop was cut at ground level on three dates. The plant parts at 0-3, 3-6 and over 6 cm, or 0-6, 6-12 and above 12 cm, respectively, for the first and the other harvests, were separated in leaf blades, petioles and stalks, and analysed for dry matter, fibre and nitrates. High yield was attained already at the second harvest, with about 62% represented by the upper plant parts. At low cutting heights the yield rose, but with a higher incidence of the basal fractions. Fibre and nitrate contents were higher in the basal parts, where petioles and stalks prevailed. As a result, cutting at greater height increased quality. Early harvest yielded sufficient biomass, unless cutting was done at ground level. Nitrate content increased with plant ageing, but not relevantly in the upper fractions. The basal parts also had high fibre contents, not compatible with acceptable quality. A harvest stage optimising yield and quality can be identified.

INTRODUCTION

Palm-tree kale (*Brassica oleracea* L., ssp. *acephala* DC, var. *sabellica* L.) is a minor form of *Brassica oleracea*, grown in some areas of the northern Apennines, (central Italy). Although described as a rare and recently rediscovered crop (Hammer et al., 1990; Hanelt, 1998), its cultivation is well established in the native areas. Traditional cultivation areas, uses and cropping systems were recently described, together with the opportunities for new ways of exploitation (D'Antuono and Neri, 1998a, b).

The perspectives for traditional Portuguese *Brassica* landraces were discussed by Monteiro and Dias (1996), who pointed out that their success as "new" products depends on consumer attitude, and that the quality of up to date products, such as frozen greens, strictly depends on flavour and texture, in turn determined by plant age and size. Palm-tree kale recently attracted the interest of the food industry for its potential as frozen vegetable. The results of previous research showed its good adaptation to intensive, high-density cropping systems, similar to industrial spinach, requiring a 60-80-day cycle in autumn as well as in spring. Nitrogen was a key factor for yield and quality, especially with respect to leaf colour (D'Antuono and Neri, 1998a). Efficient mechanical harvest requires a minimum biomass yield, with specific quality characteristics for subsequent processing.

This research was a further contribution to the evaluation of palm-tree kale as an intensive crop, particularly aimed at: a) analysing the possibility of scaling up production from plot to commercial level; b) checking the findings of previous experiments; and c) examining yield and quality variation as a function of cutting height.

MATERIALS AND METHODS

A field trial was established at Cesena (northeast Italy). A 3500 m^2 plot was sown

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with a SAIS (Società anonima italiana sementi) palm-tree kale selection. Sowing was done by a mechanical drill, at a target density of 250 plants.m^{-2} on 11 September 1998. Fertilisation was only applied as abundant manure, in the form of wastes from a vegetable processing plant. No weed control, pesticide or insecticide was needed.

The experimental treatments were three cutting heights and dates. Dates were 27 October, 11 and 24 November 1998. Cutting heights were 0, 3, 6 cm, on 27 October, and 0, 6 12 cm, on the two other dates. Cutting heights were simulated by cutting at ground level three randomly selected, 6-m^2 plots per thesis, and then subdividing a representative subsample in fractions corresponding to the three cutting heights.

The following traits were determined: total above-ground biomass; its partitioning in the fractions obtained from the different cutting heights (respectively 0-3, 3-6, above 6 cm or 0-6, 6-12, above 12 cm, according to cutting date); dry-matter content; biomass partitioning into stalks, leaf petioles, green and yellow laminas, for each height fraction; nitrate and crude fibre of each fraction; specific area and chlorophyll of green blades.

Nitrates were extracted from 1 g dry powdered sample with a 71:10:5:14 aluminium sulphate:sulphaminic acid:boric acid:silver sulphate extracting solution, and analysed by an ion-selective electrode. Crude fibre was determined according to Weende (AOAC, 1975).

Specific leaf area was calculated from the ratio between blade area (Δ-T electronic area measurement system) and dry weight. Chlorophyll was determined by grinding a sample of 50 g leaf under liquid nitrogen; a 0.5 g subsample was extracted with 80:20 acetone:water solution, and kept in a refrigerator in the dark for 12 hours. After filtration, the sample was read with a spectrophotometer at 664 and 647 nm.
All data were subjected to an analysis of variance.

RESULTS

Total biomass (Table 1) markedly increased from the first (27 October) to the second (11 November) sampling, without further relevant increase at the third harvest. In all cases, most biomass (>60 %) was present in the upper plant part.

On average, leaf laminas represented 24-28 % of the total fresh biomass, with only slightly significant interaction between cutting height and sampling date. However, big differences were observed in the composition of the three cutting-height fractions (Table 2). In fact, the upper fraction mainly consisted of leaf laminas (62-65 %), with the remaining biomass represented by petioles and only a small fraction of stems (<5 %). The proportion of laminas in the upper fraction did not depend on the cutting date, as indicated by the absence of significant "cutting date x height" interaction. The lower and intermediate fractions, however, were mainly represented by stems and petioles, with only a low amount of blades. The percentage of yellow leaves was low in all fractions. Dry-matter content (Table 3) followed a characteristic pattern. In fact, it decreased from the basal to the middle fraction, where less lignified stem parts prevailed, and attained the highest value in the upper part, because of the higher blade percentage. Dry matter markedly increased from the second to the third sampling, as a result of decreasing temperatures during late autumn, as also previously observed (D'Antuono and Neri, 1998a).

Nitrate content (Table 3) was very high and markedly rose from the first to the third sampling date, except for the upper fraction, where it attained a lower level in the second sampling date, as indicated by the significant "cutting date x height" interaction.

Crude fibre (Table 3) was also affected by the interaction of cutting date and height. In fact, fibre content of the bottom layer increased with delayed harvests, as a result of stem lignification; that of the middle fraction remained almost constant, whereas that of the upper parts markedly decreased from the second to the third sampling, as a result of leaf expansion, which reduced the ratio of vascular to parenchymatous leaf tissues.

Specific leaf area and total chlorophyll of leaf laminas (Fig. 1) followed a similar pattern, as a function of the cutting date. In fact, both increased from the first to the second sample, and markedly decreased at the last harvest date.

DISCUSSION AND CONCLUSIONS

Palm-tree kale confirmed its excellent properties to grow at high plant density and, therefore, to exploitation according to industrialised production systems.

Profitable mechanical harvest and subsequent processing require a minimum of about 20 tonnes.ha^{-1} fresh matter. In the present experiment, this level was attained 45 days after sowing, with cutting at ground level. This option, however, would give a product with high fibre and nitrates, due to the high incidence of stems and petioles. Contamination with soil would also be unacceptable. At 60 days from sowing, the critical biomass level was attained at 12 cm cutting height, with greatly positive impact on internal quality and cleanliness. Further harvest delay did not markedly increase biomass; some effects on quality were positive, such as the higher leaf dry matter and thickness, which improve the efficiency of industrial processing, and lower fibre, which may improve consumer acceptance. However, delaying harvest in the autumn cycle had negative effects on nitrate content and leaf colour. It should be noted that nitrate content, rather low in previous experiences (D'Antuono and Neri, 1998a), was very high in this trial, because of the high available soil nitrogen (> 400 kg ha^{-1}). Palm-tree kale, therefore, did not show a particular aptitude for low nitrate accumulation in rich soils.

Palm-tree kale confirmed to be a high-value new industrial crop, whose optimum yield and quality are attained by carefully tuning harvest date and cutting height.

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Tables

Table 1. Biomass yield and partitioning in the three cutting-height fractions. (1): data referring to the specific fraction; (2) data referring to the cumulative biomass, from the top of the plant to the lower limit of the fraction (ground level for the bottom fraction). Non-significant (*ns*) or statistically significant at P<= 0.01 (**).

	biomass (kg ha^{-1})				fraction (fresh m.)	
	fresh		dry		(kg kg^{-1})	
	fract.(1)	cum.(2)	fract.(1)	cum.(2)	fract.(1)	cum.(2)
harvest: 27-10-98						
0-3 cm	2467	19170	200	1665	0.127	1.000
3-6 cm	3306	16703	213	1465	0.172	0.873
> 6 cm	13397	13397	1252	1252	0.701	0.701
harvest: 11-11-98						
0-6 cm	5453	34469	406	2811	0.158	1.000
6-12 cm	7948	29016	496	2406	0.230	0.842
> 12 cm	21068	21068	1909	1909	0.612	0.612
harvest: 24-11-98						
0-6 cm	5443	37837	500	3824	0.145	1.000
6-12 cm	8397	32394	662	3324	0.222	0.855
> 12 cm	23998	23998	2662	2662	0.634	0.634
Significance						
Harvest date	**	**	**	**	ns	**
Cutting height	**	**	**	**	**	**
Harvest x cutting height	**	**	**	**	**	**

Table 2. Fraction of plant parts (stalks, petioles, leaf laminas and yellow leaves) in the crop fractions obtained from the different cutting heights. Non-significant (*ns*), statistically significant at P<= 0.05 (*) or P<= 0.01 (**).

	fraction fresh biomass (kg kg^{-1})			
	stalks	petioles	laminas	yellow leaves
harvest: 27-10-98				
0-3 cm	0.573	0.218	0.102	0.103
3-6 cm	0.472	0.430	0.050	0.048
> 6 cm	0.040	0.327	0.617	0.015
harvest: 11-11-98				
0-6 cm	0.637	0.248	0.075	0.040
6-12 cm	0.348	0.525	0.103	0.020
> 12 cm	0.043	0.287	0.655	0.017
harvest: 24-11-98				
0-6 cm	0.267	0.248	0.147	0.026
6-12 cm	0.218	0.525	0.173	0.026
> 12 cm	0.196	0.287	0.178	0.023
Significance				
Harvest date	ns	ns	*	**
Cutting height	**	**	**	**
Harvest x cutting height	ns	**	ns	**

Table 3. Quality characters of the product from the three different cutting-height fractions. (1): data referring to the specific fraction; (2) data referring to the cumulative biomass, from the top of the plant to the lower limit of the fraction (ground level for the bottom fraction). Non-significant (*ns*) or statistically significant at P<= 0.01 (**).

	dry matter kg kg^{-1}	nitrates on fresh matter (mg kg^{-1})		fibre on dry matter (kg kg^{-1})	
	fract.(1)	fract.(1)	cum.(2)	fract.(1)	cum.(2)
harvest: 27-10-98					
0-3 cm	0.081	7384	6578	0.192	0.171
3-6 cm	0.064	8839	6469	0.183	0.168
> 6 cm	0.093	6066	6066	0.165	0.165
harvest: 11-11-98					
0-6 cm	0.075	9630	6973	0.312	0.188
6-12 cm	0.062	10189	6524	0.195	0.166
> 12 cm	0.091	5576	5576	0.158	0.158
harvest: 24-11-98					
0-6 cm	0.092	12799	8419	0.318	0.141
6-12 cm	0.079	12929	7756	0.169	0.115
> 12 cm	0.111	6467	6467	0.102	0.102
Significance					
Harvest date	**	**	**	**	**
Cutting height	**	**	**	**	**
Harvest x cutting height	**	**	ns	**	**

Figures

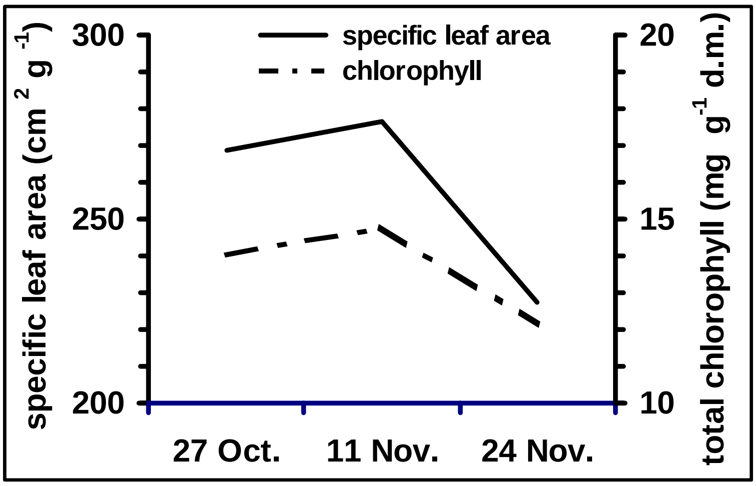

Fig. 1. Pattern of specific area and chlorophyll content of leaf laminas, as a function of cutting height, at final harvest. Effect of harvest significant for both traits.