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Composting of bio-waste and green material

Systems and costs

In Germany the separate collection of bio-waste from other waste is now carried out almost countrywide. The composting of fresh plant material and so-called bio waste is mostly undertaken by the local authorities with their own plant, or by private enterprise. This task can also be interesting as an additional income source for farmers, especially when existing machinery, facilities and areas can be used. In the following report representative system variants which have been tested under practical conditions are defined, and their financial viability including specific costs (DM/t processed waste) investigated.

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Several system variants and sub-variants were defined for the calculation of costs in smaller composting plants (≤ 6500 t/a throughput) (*table 1*). Constructional and machinery-technological plant in working systems were used as models in this work. Alongside the variants in table 1, sub-variants considered were as follows:

A_1: as A, plus utilisation of former silage pit [1, 2]

D_1: as D, but no roofing, utilisation of former silage pit

F_1: as F, but throughput of 6500 t/a

For the calculation, different plant areas were differentiated in association with the system and machinery technology (open areas sealed and fitted with drainage channels):

- temporary storage for the composting waste,
- composting area,
- transport and working area,
- storage area,
- areas for infrastructural equipment,
- temporary storage area for waste water and roof water collection,
- fencing for the plant area and door.

Comparison of selected system variants

The specific area utilisation (sealed surfaces/throughput capacity) reduces from A to E. Above all, this is caused by the different inversion machinery used and the associated size of heaps.Through the processing of bulky materials and the longer composting time involved the specific area requirement for the green material processing variants F and F_1 is high. Because of the lesser inversion frequency and the limited intensity of the microbial degradation process the composting time increased from type A to F (with the exception of E). In type E, a forced ventilation of the heaps led to faster microbial degradation and shortened composting time.

Table 1: Characteristics of different composting processes (x = available; - = not available

System type	A	B	C	D	E	F
Type of waste	B, G	B, G	B, G	B, G	B, G	G
Throughflow capacity (t/a)	1600	6500	6500	6500	6500	1600
Sealed area (m^2)	3050	7600	6000	4400	4300	1850
Specific area utilisation (m^2/t)	1,9	1,2	0,9	0,7	0,7	1,2
Delivery and conditioning						
Sorting-out undesirable materials (manual)	xx	x	x	x	-	-
Chopping structured material	ü	ü	ü	ü	ü	be
Roofing	-	-	x	x	x	-
Weighbridge	-	x	x	x	x	-
Main composting process						
Period (weeks)	8	8	8	12	3	12
Form of heap	Triangular	Triangular	Triangular	Trapezoidal	Row	Trapezoidal
Heap dimensions (BxH, in m)	3 • 1,5	3 • 1,5	5 • 2,4	7 • 4	6,5 • 2	7 • 4
Inversion machines	tg	S	S	R	R	R
Inversion process	16	12	12	5	0	3
Roofing	-	-	x	x	--	-
Compost heap ventilation	-	-	-	x	x	-
Post-composting						
Period (weeks)	4	8	8	5	4	12
Form of heap	Triangular	Trapezoidal	Trapezoidal	Trapezoidal	Trapezoidal	Trapezoidal
Heap dimensions (BxH, in m)	3 • 1,5	6 • 2,5	6 • 2,5	7 • 4	13 • 2	7 • 4
Inversion machines	tg	R	R	R	R	R
Inversion process	4	2	2	2	0	1
Roofing	-	-	x	x	-	-
Further-processing, other work						
Compost sieving	ü	ü	ü	ü	ü	ü
Sorting-out undesirable material	-	ha	a	a	ha	-
Machinery shed	x	x	x	x	x	x
Fuel store and filling station	-	x	x	x	x	-
Office, social area, Sanitary facilities	-	x	x	x	x	-

B organic refuse from special collection bins; G green waste; ü shared farm facilities; be farm-owned; R 4-wheel loader; S self-driven; tg tractor-pulled; ha semi-automatic; a automatic

System variants	Calculation bases	A	A1	B	C	D	D1	E	F	F1
Building investments		829063	131848	2420875	2833769	2102757	424678	1916928	532507	1608456
Specific building investments (DM/t input)		518	82	372	436	324	65	295	333	247
Capital servicing costs										
Composting technology	Writing-off over 10 y, interest 6.5%	-	-	-	-	-	-	90418	-	-
Building plant	Writing-off over 10 y, interest 6.5%	115327	18341	336755	394191	292503	59075	176236	74074	223744
Mach. technology	Writing-off over 7 y, interest 6.5%	25180	25180	84055	118515	32820	32820	32820	54699	86607
Total capital servicing costs		**140507**	**43521**	**420810**	**512706**	**325323**	**91894**	**299473**	**128774**	**310351**
Running costs										
Servicing, repair and running costs										
4-wheel loader 1	*)	9159	9159	13356	19080	32245	44361	24804	9540	38804
4-wheel loader 2	*)	-	-	10074	18508	-	-	-	-	-
Tractor	*)	3263	3263	-	-	-	-	-	-	-
Inverter	Manufacturer information	6072	6072	6448	15926	-	-	-	-	
Chopper	*)	-	-	-	-	-	-	-	9042	32251
Sieve machine	*)	-	-	-	-	-	-	-	-	2388
Building plant and composting techn.	Building technology 3%, composting technology 5% Investment total	24872	3955	72626	85013	63083	12740	70508	15975	48254
External labour										
Chopp. green waste	8 DM/m³**)	8000	8000	12000	12000	12000	12000	12000	-	-
Composting	3,50 DM/m³**)	5051	5051	18351	18351	18351	18351	18351	7452	-
Recycling waste water/Removal	6,50 DM/m³**)	7800	7800	17950	7618	5935	11681	9997	5090	13351
Remaining waste removal	2 Gew.-% of delivered amount 300 DM/t	9600	7200	39000	39000	39000	39000	39000	2400	9750
Marketing and analysing	***)	4012	4012	4845	4845	4845	4845	4845	4012	4845
Other running costs										
Personnel costs	*)	43601	43601	127438	127438	127438	127438	87203	43601	87203
Insurances	Information from insurance companies	700	700	3000	3000	3000	3000	3000	700	3000
Energy costs		-	-	2000	2000	5000	2000	30000	-	2000
Total running costs		**119731**	**98813**	**327088**	**352779**	**307897**	**275416**	**299708**	**97812**	**241846**
Total costs		**260237**	**142334**	**747898**	**865485**	**633220**	**367310**	**599181**	**2265 86**	**552197**
Specific costs (DM/t input)		**163**	**89**	**115**	**133**	**97**	**57**	**92**	**142**	**85**

Table 2: Total costs of different composting processes (DM/year)

*) KTBL data collection countryside care; **) farm information, averages; ***) Federal material composting society e.V. (Subscription and material inspection; costs of compost analysing)

Building investments

Table 2 contains the calculated building investments for all system variants.

In the comparison of newly built plant types costs in system A are the highest at 518 DM/t input because of the high specific area requirements. A re-utilisation of existing constructional facilities led to improved cost savings.

High investment costs in variant B compared with the systems C, D and E which have the same throughput, but different technology, resulted through the system's high area requirement for the main composting process. The highest specific investment costs of all 6,500 t plants were for system C because of the area of roofed plant. Lower investment costs were calculated for system D because area requirement and the extent of roofed area were limited. In system E the cost of the special composting technology had to be born in mind. However, these are so low that the system worked out the cheapest compared with systems B to D.

With green material composting plants (types F, F_1) the longer composting time in total led to a higher area requirement and thus high building investment costs, despite space-saving trapezoidal compost heaps.

Machinery investments

The economic viability of composting machinery purchase was determined through a comparison of annual costs for performance established through use over several farms with machinery costs from other systems. Thus an individually-owned material chopper was shown to be uneconomical for all bio-waste composting variants but viable, however, for both green material composting plants.

For the bio-waste composting plants, sharing a compost-sieving machine between farms is more cost effective. For the green material composting plants, buying a sieve machine (performance: 50 kW/ 80 m³/h) was only economical from a throughput of 6500 t/a upwards.

All machines were considered with 100% utilisation on the respective plants with the exception of the tractors (A, A_1; with the application of a pulled heap inverter) for which 20% utilisation on the plant was applied.

Total costs

These comprise the capital servicing costs as well as the actual running costs which are produced from:

- variable machinery costs,
- servicing and repairs of constructional and composting technology,
- insurance and energy costs,
- external labour and
- personnel costs.

In addition to a representation of total costs, *table 2* contains information regarding the calculations (all costs without purchase tax proportion).

The specific costs (costs per year and throughput) were highest for the new-built 1600 m³ plants (types A and F) at 160 DM/t. Utilisation of facilities formerly used for other purposes (types A_1 and D_1) represent in each case the most cost-effective variants in comparison with same-throughput plants. System E (special compost technology) had the lowest specific costs when compared with the other new-built 6500 m³ bio-waste composting plants.

As a rule, the specific costs are the basis for tenders and for this reason reflect the actual minimum price for services in the refuse collection sector. The price drops which have occurred in this sector in recent years force tenders to be calculated more precisely and result especially in new plants being more cost-efficiently built and also in the application of alternative, more rational, composting systems. Thus the trend is towards larger throughput plants (up to 6500 t/a, up until now still suitable for building permission under the building laws) with improved area exploitation (trapezoidal and table heaps instead of triangular ones); doing without roofing over the composting area, and minimum use of machinery (no heap inverters). As a rule, smaller plants are not competitive.