This is the published version of a paper presented at *Textile Intersections*.

Citation for the original published paper:

On Textile Farming: The Interior as an Ecosystem
In: London
https://doi.org/10.17028/rd.lboro.9724718.v1

N.B. When citing this work, cite the original published paper.

Permanent link to this version:
http://urn.kb.se/resolve?urn=urn:nbn:se:hb:diva-21961
On Textile Farming: The Interior as an Ecosystem

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On Textile Farming: Towards an Interior Ecosystem

SVENJA KEUNE, Swedish School of Textiles, Boras and Svensson AB, Kinna, Sweden

In Greenhouses horticultural textiles create healthier climates for plants, protecting from wind and insects, and improving and guiding the light. Likewise, indoors traditional interior textiles mediate between people and space, creating indirect light through shielding the sun in a window and making a cold and hard bench feel more soft and look more colourful. Moreover, today horticultural practices increasingly enter the private realm since urban gardening and indoor gardening systems very popular and architects continue to propose joint living spaces for people and their vegetable cultivation in order to promote more resilient and sustainable ways of living. Rahm argues that we could create interior spaces which are more natural than the exterior by reformulating the specific conditions of a natural milieu inside a building. Indeed in recent years, the interest in plants as a vital material in an architectural context increased and has adopted various appearances which have in common their temporary expressions and a certain level of transience and arbitrariness for plant growth. However, many of the examples are characterised by rigid materials and technical systems that lead to expressions that seem less natural. In relation to this ‘On Textile Farming’ explores textiles as a flexible system to integrate plant growth. The collaboration in this research with Svensson AB, a developer and producer of textiles for interiors and greenhouses, has led to a joint approach towards these two distinct areas, climate screens and interior textiles. By experimental methods, the interaction between plants and textiles is explored, using double weave constructions as a framework for seeds and substrate to be integrated. As a result of this project the two concepts ‘Textile Permeability’ and ‘Textile Climate’ are proposed; they describe the interactions between plants, textiles and space which are seen as a first step towards a textile interior ecosystem in which spaces are composed of relationships between biotic and abiotic components and natural and artificial therefore intersect. Here textiles could become a flexible interface guiding and melting into seasonal expressions of e.g. growth and decay.

Additional Key Words and Phrases: textile farming, designing with seeds, textile design, biomaterials, spatial design, seasonal interiors, plant adaptations

1 INTRODUCTION

At Svensson AB, where this research was conducted, interior textiles and horticultural textiles are developed in two distinct departments. Thus, both categories of textile products aim to create better climates for plants and people separately. In Greenhouses horticultural textiles create better climates for plants; indoors traditional interior textiles mediate between people and space, creating a more comfortable climate for them. In interiors textiles are used e.g. to make a cold and hard bench feel more soft, to highlight certain areas through colours, to represent the season, and to create indirect light through shielding the sun in a window. With an increasing interest in forms of urban gardening, e.g. integrating a small vegetable cultivation into the home, horticultural methods and systems for plant cultivation enter the interior. Often these are based on rigid materials and shelving systems and exclude the natural biotic environment in which plants used to thrive in nature. Rahm argues that nature has always been excluded from interiors and that now as it doesn’t exist anymore and the whole world including external environments and their climates have been altered by human activity, we could create interior spaces which are more natural than the exterior by reformulating the specific conditions of a natural milieu inside a building [1]. Indeed in recent years, the interest in plants as a vital material in an architectural context increased and took on various appearances which is illustrated e.g. by Grüntuch-Ernst in the publication ‘Hortitecture, The Power of Architecture and Plants’. The publication presents current developments in an architectural context: façades as bio-receptive panels to host microorganisms, cryptogams, and more complex plants are researched by Cruz and Beckett, Ludwig investigates living plant constructions to support or facilitate architectural form-works and Weisel utilises ropes to vertically organise plants as a façade system that produces edible plants and improves the buildings climate [2]. At the same time, there is a rising awareness about the abilities of plants to sense, act and communicate, their symbioses and other important processes such as cleaning water and air, providing oxygen, and storing CO2 [3]. At the material scale, the interest in living biomaterials e.g. bacteria, fungi, algae has reached the textile design practice as well. Textiles are grown from roots [2], bacterial cellulose [4, 5] or mycelium [6, 7] and dyed [8, 9] or transformed with bacteria [10]. This biological paradigm brings an alternative perspective to the ways in which textiles and interiors can be designed and lived with. The collaboration in this research with Svensson AB inspired to an approach which speculatively connects the companies two distinct areas: interior textiles and climate screens. By experimental research methods, the
interactions between plants and textiles are explored through using seeds as a dynamic material for textile design and investigating double weave constructions as a framework for seeds and substrate to be integrated. As a result the concepts 'Textile Permeability' and 'Textile Climate' present a perspective in which textiles become a flexible interface guiding and melting into seasonal expressions of e.g. growth and decay. Both concepts are seen as a first step towards a textile interior ecosystem in which spaces are composed of relationships between biotic and abiotic components and natural and artificial therefore intersect.

2 EXPERIMENTAL WORK

The approach taken to enable and investigate textile plant interactions involves the creation of woven enclosures for the integration of seeds and substrate, to direct plant growth through different densities of the weave construction, to create microclimates in and around the structures through the interaction between climatic parameters, e.g. light intensity, relative humidity and temperature (Figure 1).

![Figure 1](image1.png)

*Fig. 1. The image illustrates the set-up of the experimental work and the experimental goal: Textile Plant Interaction*

2.1 Set-Up

![Figure 2](image2.png)

*Fig. 2. The image shows the design for the woven samples which were produced at Svensson AB.*
The construction of samples is based on double weave constructions in which two warps are woven separately in defined areas to enable enclosures into which seeds and substrates can be inserted (Figure 1). The foundational weave construction connects both warps (the brown and purple areas in Figure 2), whereas the coloured circles mark the areas which create enclosures and in which different bindings were explored. Plain weave, satin weave, basket weave, twill weave and aida weave were therefore combined and the samples woven with an industrial Picanol Jacquard loom at Svensson with a full size rapport, using a standard material for the interior textiles, a mix of wool and polyamide. The composition of the samples and their set-up is illustrated in Figure 3.

By separating warp and weft with the help of the tip of a bobbin (Figure 4) a hole was created in order to insert seeds and substrate e.g. soil or cotton padding into the envelope by hand (Figure 4-7) or by using a funnel. To close the holes weft and warp threads were put back into place (Figure 7).

2.2 Explorations

#1
Fig. 8-13. Sprouts permeating the twill (8, 9, 11, 12) and the aida weave construction (10, 13). Figures 11-13 show the different stages of development, while some sprouts are already withering, two other types start to appear.

The first exploration was carried out with a large circular envelope with twill weave on one side and aida weave on the other. It is filled with soil and a number of different seeds and placed vertically. After some days of watering a number of sprouts managed to permeate both constructions in different areas of the entire face (Figures 8 and 9) and back of the envelope (Figure 10). White stems and bright green leafs which reach against gravity and grow in line with the warp, white roots appear in the bottom of the enclosure, illustrating their gravitropism, their growth response towards gravitation (bottom Figure 8). At the same time as the small sprouts collapse and wither, which means that they lose their force to direct themselves against gravity, that they shrink and change colour, two other types of sprouts appear in the very top (Figures 12 and 13).

#2

Fig. 14-15. Figure 14 shows a lacinato kale sprout hiding inside a large circular envelope, Figure 15 reveals the development of the sprout by cutting open the front of the enclosure.

The second exploration was carried out with a large circular envelope woven with plain weave and basket weave and loosely filled with soil to which a hand-full of lacinato kale seeds were added. Since there was no visible evidence for growth for weeks of regular watering, a hole was created into the top part of the vertically oriented structure to see if there were some hidden transformations inside the textile envelope. The hole revealed the stem and leafs from a lacinato kale sprout hiding inside the textile (Figure 14). The lack of radiation caused the yellow colour of the leafs. Figure 15 illustrates the transformation by exposing the inside through cutting out one side of the enclosure.

#3
The third exploration was carried out with a two-piece set of circular envelopes for which twill and aida weave were used. Both rings were densely filled with soil and a borage plant integrated into the center of the middle one. Figures 16 and 17 show the backside of the structure, where a number of roots permeated the bottom of the central enclosure and the adjacent envelope to expand its root system.

The fourth exploration was carried out with a large circular envelope with a three-piece set of adjacent circular enclosures woven in plain and satin weave. The central one was filled with soil and a hand full of radish seeds and placed in a horizontal orientation. After a couple of days red roots appeared outside the envelope (Figure 18), the face remained the same. To help the sprouts permeate the weave construction small holes were created by separating warp and weft and one sprout appeared (Figure 19). To provide a suitable microclimate for the roots to develop, a bowl with soil was placed underneath the structure. The red roots together with the particles of soil create an aesthetic opposition on the area where the white warp intersects with a green and petrol weft but creates an aesthetic blend in relation to the middle ring, where the black warp interweaves with a light blue and rose weft.

3 ANALYSIS OF THE SAMPLES

The first exploration in which twill weave and aida weave form a large enclosure densely filled with soil provides a structure which seems suitable for the sprouts to work themselves through the construction in the back and in the front. Twill weave and aida weave are both categorised by floats which create an open weave fabric, making it more easy for the plants to interact with the construction and to permeate it.

The second exploration in which plain and basket weave were used provides a rather impermeable backside and a loose front, since plain weave is a dense weave construction and very durable and basket weave has a loose textile quality through warp and weft threads which interlace in groups, resulting in a checkered appearance and a soft quality. It was due to the shape and form of the leaves, which were already too big and offered too much resistance that the plants did not fit through the construction and remained below. Therefore the relations between placement of the seeds, type of germination, permeability of the weave construction and time determine the interaction between plant and textile. Since there was no appearance of roots it could be concluded that the sprouts, at the time of observation, found enough nutrients, moisture and space to root in. This was not the case in the third exploration, where a borage plant extended its root system into the adjacent enclosure like a seam. The appearance of
roots outside the textile envelope could be interpreted as search for better conditions and additional resources. In a horizontal orientation roots have less vertical space and substrate to expand in, the combination of little distance between seeds and textile and little soil in vertical direction increases the likelihood that they appear above ground quite shortly after germination, since they reach towards gravity rather than expanding horizontal. The orientation of the structure and the amount of substrate vertically available thus have a say in the life span of the integrated plant, which could be observed in the fourth exploration. The more substrate, the more moisture is available and the longer it takes for it to evaporate. However, roots above ground could be seen as a textile application since they share many similarities with threads. In the fourth exploration the plain weave construction in combination with the seeds and substrate density prevented the stems and leaves from permeating the textile construction, the roots however managed to enter through the satin weave due to their pointy tip and growth power.

4 TEXTILE PERMEABILITY AND TEXTILE CLIMATE

Fig. 20-22. The figures show rosemary, pea and grass plants (from left to right) in textile envelopes in a vertical orientation. The first two structures were places indoors, the third one was placed in between inside and outside.

Regarding the textile influence on the interior environment, the examples open up for two concepts. ‘Textile permeability’ and ‘textile climate’ condition each other and are both attempts to guide growth and enable interactions. Textile permeability enables interactions between plant and textile, and what is inside and outside of the textile envelope. The inside can be referred to as below ground since it is mostly a storage of moisture and seeds with substrate for root systems. Since the climatic conditions inside the envelopes in relation to relative humidity, light intensity and temperature differ from the space around, one can say that a textile climate emerges which together with the level of textile permeability determines the conditions for plants e.g. to be activated, to thrive, to interact with the textile, to wither and to die, consequently their development enabled or restricted. Figure 20 illustrates a textile structure with rosemary plants in a window, as a sun-loving plant the structure can be turned towards the sun over the course of a day. The pea plants in figure 21 use the permeable weave structure to climb, both figures are thus exemplifying the concept of textile permeability, whereas figure 22 illustrates a changing textile climate by showing a gradient of withering grass.

The textile creates a spatial division between the space enclosed by the envelope and the space outside of it and mediates between both microclimates. Temperature, relative humidity and light intensity over time are major climatic parameters for the onset of germination, whereas the availability and the amount of nutrients becomes more important over time. The textile climate guides the lifespan of the incorporated plants. Dormant states are triggered by conditions in which moisture is absent or terminated to initiate dormancy or the death of plants as a form of preservation of a certain state of growth, e.g. leaves prior to flowering or flowers. Transformative states are triggered by states in which moisture is present. The spatial separation by the textile represents the division between below ground and above ground and consequently the division between roots and shoot and their processes: shoots are in search for light above ground and roots in search for water and nutrients below ground. However, whereas the space
above ground is almost limitless, the space below, inside of the textile, is not. Since there is a balance between the space a plant takes above and below ground, the space below ground that a plant has access to determines its development.

Seeds can be located in textile envelopes in different areas, as one per pocket or many. When horizontally orientated, the seeds can be placed vertically in the through substrate expanded textile envelope. Here they can be located in the top, close to the face construction to e.g. provide maximum space for the downward root development and minimum distance for the up-reaching stems and leaves. The seeds can be placed in the bottom, close to the rear construction to e.g. let roots appear at the rear and to impede the penetration of the face construction by the stems and embryonic leaves. They can also be placed in between, with the same distance to face and back e.g. to observe the timely differences in root and shoot development (Figure 20). On the horizontal axis, they can be located in the corners of a textile envelope to e.g. accentuate them or in its centre to e.g. provide maximum substrate to the growing plant, as the expansion of the envelope creates most space in the centre (Figure 21).

In a horizontal orientation, there is an up-facing side, the face, and a down-facing side of the cloth, the rear. The face is usually exposed to light, which is absorbed or reflected by the textile structure and its containing elements, e.g. substrate and by the ground on which it is placed. The seedling in a horizontally placed textile envelope consequently responds to Phototropism with the parts close to its face. The microclimate at the back is warm and moist. The roots, effected by gravitropism consequently grow down and outwards of the envelope in search for a dark, moist and warm environment (Figure 22).

Fig. 20-21. Figure 20 illustrates a vertically oriented textile envelope and figure 21 a horizontally oriented envelope and the positions of the seeds within.
Fig. 22 illustrates a textile structure in a horizontal orientation and the microclimates that emerge inside and around them.

The space available to the plants below ground can be determined by the size of the textile envelope but also its orientation. In a 90°, vertical position, the inside of the envelopes, the part below ground, takes on a vertical direction. Here, seeds can be placed differently within the structure.Situated in the top of a textile envelope, the entire lower part of it is available for the roots to expand in, whereas it is more likely that roots will appear above ground, on the lower part of the envelope, the lower the seeds were placed. Other important factors for the appearance of roots are of course the size of the envelopes in relation to the plant growth pattern in relation to time.

Fig. 23 illustrates a textile structure in a vertical orientation and the microclimates that emerge inside and around them.

The vertical structure can direct the plants towards light or keep them in shadow (Figure 20). Here the textile climate is more important, e.g. the level of moisture and the temperature. A vertical orientation means that the hosted plants have more substrate in direction to gravity to root in, but they are also more exposed to e.g. light, air and wind (Figure 23). Available humidity sinks down towards gravity. The vertical placement, in comparison to the horizontal orientation, contains a more diverse textile climate, drier and warmer in the top, more humid and colder in the bottom, it is space-saving and easy to move or turn towards spots with e.g. direct sunlight for sun-loving plants. The flexibility and mobility of a vertical textile makes the plants position more flexible and adjustable to their needs. The vertical position is therefore more suitable for growing plants in favour of the plants development (biological perspective), whereas the horizontal orientation is more suitable for growing plants in favour of textile expressions (textile perspective).
In addition to the effects that the concepts have on textile design, there are also effects and conditions that relate to interior design. Since certain plants need certain environments and climatic conditions, spaces need to be analysed or designed for being suitable habitats for plants. The textiles can also mediate outside-to-inside transitions as illustrated in Figures 24 and 25, where a textile structure temporarily replaces a wall (Figure 24), protects the inside from wind and rain, while it absorbs moisture which is needed by the plants which grow in the fabric. Such a modularity demands some kind of spatial permeability as well, which could be understood as the flexibility of spaces to open and close, rearrangements, enabling access to outside experiences and expressions which could be mediated by the textiles. Consequently seasons, planting and harvesting times also affect the everyday life in the home. Everyday routines change and the time and attention that is and must be directed towards the textiles and their plants increases, unless the plants can provide themselves with e.g. water, or insects for pollination, by the textiles connection to the outside and a permeability of the space.

5 DISCUSSION

In the context of this work textiles are used to integrate plants and to create comparisons with them in order to develop an understanding about how an interaction between plants and textiles could be designed, initiated and guided. Here the modularity and flexibility of textile structures, which is termed ‘Textile Permeability’, is a way to adapt and respond to environmental influences but to also guide growth over time. Through the amount of substrate and moisture available, the structures allow a certain life span...
for the integrated plants which could be thought of as inbuilt expiry date. Through the integration of growth, expressions thus become temporary, their change can be activated and deactivated, their state can be active or dormant. Since a biological perspective is added to the life-cycle of interior textiles, expressions and events usually found outdoors enter the interior. Substrates and water could create dust, puddles and mud, certain plants need pollination. Consequently temporal expressions dominate permanent expressions and 'Seasonal Interiors' can be designed and guided.

The explorations into interactions between plants and textiles involve considerations about the blueprint of the plant, e.g. its type of germination, its colour in different stages, its climatic preferences, the construction of the weave, weather it is dense or loose, and the orientation of the fabric, vertical or horizontal. They are determined by the prevailing climatic conditions over time (Figure 26).

![Fig. 26. This figure illustrates a model for designing interactions between plants and textiles based on woven structures.](image)

The design process becomes more complex, since the needs, e.g. amount and quality of light, space above and below ground, mix of nutrients and expressions of the plants in relation to time e.g. colours of the different parts over time, spatial expansion, directionality (standing, creeping, climbing) need to be considered. This automatically includes considerations about the positioning of the plants in relation to the textile (placement of the seed) and in relation to space (e.g. vertical or horizontal orientation, sunny or shady position). The textile perspective to plants on the other hand changes the view on plants and their development. The similarities in colour or shape, or that of roots and threads can be used to design temporal expressions which support the textile qualities rather than the full development of the plant.

Both concepts 'Textile Permeability' and 'Textile Climate' promote an intersection of horticultural thinking and textile design methods and practices. Textiles are suggested to integrate plants to create active and adaptive surfaces by using seeds as a dynamic material for textile design and to create more flexible modes of plant organisation indoors. In this work textiles are consequently proposed as a framework for growth, which connects to the works introduced in the context of this paper. Cruz & Beckett [11] argue that "the degree of colonisation on surfaces is dependent on both the inherent properties of the material itself and environmental conditions; this area of work asks design to explore the relationship between the material substratum and areas of the surface that enhance or inhibit growth, as well as the specific environment and organisms that thrive in it". They explore morphological features such as porosity and roughness through which e.g. moisture is collected and retained to promote the growth of cryptogams. It is the common interest in morphological surface qualities in relation to environmental conditions which together promote plant growth that connect this research with the work of Cruz & Beckett. Textiles offer a high flexibility and permeability, 'Textile Permeability' therefore is seen as a way of designing 'bio-receptivity' through weave-constructions which result in e.g. interactions between roots and threads from a functional and aesthetic point of view. Such interactions can be observed in the work of Weisel and the hydroponic rope systems. Whereas Weisel utilises ropes 'On Textile Farming' explores double weave constructions to inhabit plants and the interplay in relation to e.g. colours and the orientation of a textile
structure. Textiles, in the context of this work are not seen as the only substrate, but as one of them and as an envelope for others. Further developments through textile engineering could focus on e.g. selective movement of moisture and nutrients in a given direction through the choice of textile material and construction, additional features for filtering the water which is running through the fabric, selective levels of resistance and decomposition within the textile structure. In relation to Svensson AB, ‘On Textile Farming’ proposes using textiles to inhabit plants and to create a beneficial climate within them instead of underneath them. The resulting material could then be installed in e.g. domestic interiors where it contributes to ways of living and growing which intersect more through e.g. interior textiles which are used as usual, then activated and which gradually transform and change places towards the outside. In relation to Beyers concept of a textile microbiome, further development into what is called here textile permeability and textile climate could be extended by beneficial microorganisms and insects which are attracted to the textile properties and the textile design, e.g. colours and patterns. Creating interior spaces which are more natural than the exterior, as proposed by Rahm, by re-formulating the specific conditions of a natural milieu inside a building, opens up the design space in many directions. One direction stretches towards post-anthropocentric modes of designing textiles and spaces, since people will share their interior living space with other organisms. Here textile design can draw from different fields to create what could become a ‘textile interior ecosystem’: horticultural knowledge about e.g. the interaction of insects and colours in terms of attraction and repulsion and climatic conditions for plants; regenerative farming about e.g. companion planting; tissue engineering about creating textile bio-receptivity. A ‘textile interior ecosystem’ could therefore be a community of people, plants and other organisms, e.g. insects, microorganisms, which live in conjunction with textiles and other abiotic components through cycles of nutrients and energy, e.g. rainwater is filtered by the textile structure and provides moisture for the plants in it. The plants filter water and air and provide nutrients for people, whereas the people manage the climatic conditions of the interior, organise the growth in beneficial groups, move and expand the textiles according to the plants needs and through e.g. fermentation provide nutrients for them. The textiles either break down and turn into nutrients or substrate, or they last and form a permanent template for growth as part of an architectural space. In this scenario ‘Textile Permeability’ and ‘Textile Climate’ serve as two building blocks towards a ‘Textile Interior Ecosystem’. In a time in which the way we handle relationships to biotic and abiotic components is discussed and criticised, this research could open up a range of concepts unfamiliar to designing textiles and spaces such as designing indoor seasons with seasonal textiles, designing textiles for companion planting and opening the interior space for multi species relationships, to support pest control and pollination. Here, textiles create connections between the scale of the material and the scale of interior space by becoming a template for growth and a mediator between all biotic and abiotic actors involved.

ACKNOWLEDGMENTS
This work has received funding from the European Union’s Horizon 2020 Research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 642328 and was supported by Svensson AB.

REFERENCES