The following articles are a mini-primer on soils, a discussion of their relationship to plants and the environment and an outline of the basic elements of French Intensive Bio-Dynamic Gardening as practiced at the UCSC Farm & Garden

THE GROWTH OF SOIL

Soil cultivation cannot be understood as merely preparing the ground for growing crops. Cultivation is a reenactment of the process of soil formation itself: the initial, ongoing and perpetual cycle of transformation which renders the earth's mineral matter into the primal terrestrial womb, a principal source and nurturer of life.

Over aeons of geological time, the earth's bedrock formations--solidified from the original molten state--were broken down, shifted, and weathered by the elements and great natural alterations. Layers of sedimentary rock formed over igneous rock under oceans and lakes; major mountain ranges thrown up by great earth movements; more recent glaciers grinding and leaving deposits over much of the planet--all these have resulted in great soil diversity.

Climactic factors were and are primary physical soil makers. Frost, wind, rain, heat, and water are the cultivators which cause mineral formations to disintegrate from larger to smaller particles; from gravel to sand to silt to clay. Climate also affects vegetation, which in turn affects the physical and chemical properties of the soil and gives rise to varying soil types. Grasslands with their sparse rainfall and subsequent extensive root systems give rise to well structured, fertile, unleached soils. In temperate forests the soil nutrients are constantly recycled via the decomposition of leaf litter.

Topography modifies the climate and affects soil formation through erosion. Living organisms (micro- and macro-) affect soil structure and chemical composition. They are responsible for the decomposition of plant and root residues, and contribute through their own decomposition. Soil life also plays a vital role in the nutrient content of a soil, which re-affects the vegetation growing on that soil. Aerobic soil organisms are great cultivators, aerating, mixing horizons, improving structure, and making the soil more erosion resistant.

EARTH, AIR AND WATER

Earth's processes, therefore, and the forces of nature are custom-made to perpetuate the eternal feedback loop to change which results in life in and out of the soil. For oun purposes, we need to understand what it is that the constant restructuring of soil provides which fosters plant growth. We have only to look at the elements which are performing the task--primarily air and water. The predominant function of cultivation in nature is to allow aeration and drainage, although these cannot be separate from requirements such as nutrients, temperature and light.

A handful of soil contains not only solid matter, but also air and water. An ideal soil will contain 50% solid matter (mineral and organic), 20-30% air and 20-30% water. The pore space between the solid particles is first occupied by water, and the remainder by air. Excess water in soil will literally squeeze the air out of it. If a soil has adequately large pores, some air will remain, even when excess rainwater logs it. Conversely, a compacted or poorly drained soil will remain so full of water that air cannot reenter.

In nature the finest, most weathered soil particles are on the surface and the lower horizons are rougher and larger, down to the parent material which is the coarsest of all. This arrangement of soil particles allows water to infiltrate the surface and gradually percolate through the soil, with the excess draining into the ground water and eventually back into streams and rivers. The plants' roots are enabled to penetrate easily through the soil and utilize water, air and nutrients with a minimum expenditure of energy. Gradations in soil horizons also permits constant renewal of soil air from the atmosphere by diffusion.

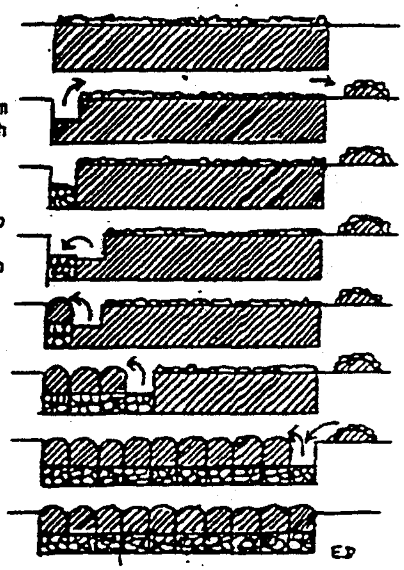
Oxygen (O_2) is the element essential to plant growth which is probably least recognized by gardeners. All parts of a plant respire--germinating seeds, roots, shoots, fruits; all need oxygen. Soil air contains less oxygen than the atmosphere, and its oxygen is constantly being used up by plant roots as well as by billions of aerobic soil microbes.

Other processes essential to plant growth are also dependent on water and air availability. Carbon dioxide is dissolved by water to produce carbonic acid, which dissolves minerals so they are more available to plants in solution. The nitrogen gas of soil air is used by soil and root nodule bacteria to produce a combined form of N_2 that plants can assimilate.

CULTIVATION AND THE RAISED BED

What takes centuries of time to accomplish in nature can be speeded up to a few short seasons by the ingenious and sensitive cooperation of humankind. Cultivation implies primarily the physical manipulation of the soil, but in truth it cannot be set apart from fertilization, watering, crop rotation, and all the practices which work together to create the optimum environment for plant growth. In the garden, we imitate, select from, and enhance nature's techniques of cultivation to create a miniature oasis of fertile, prolific, living soil which is the raised bed.

The biodynamic-French-intensive raised bed mimics nature's own soil dynamics by employing a system of deep cultivation which produces the essential aeration and drainage. It is the introduction of air into the soil which causes the bed to be raised. Timing of cultivation is important--digging when the soil is neither wet and sticky nor dry and dust-like. Breaking up of clay subsoils; planting deep-rooted crops whose roots fracture the subsoils and leave air channels when they decompose; the addition of organic matter by trenching in green manure and adding composts and aged manures--all are important replications of nature's own methods of creating potent soil. Another important feature of raised beds is the permanent placement of beds and paths. Because the beds are never walked upon, there is minimum compaction of the soil in the growing area; better retention of structure, aeration, and drainage; and therefore better plant growth. Ideally, the raised bed should be on a gentle south-facing slope to increase solar exposure and to enhance air flow in the garden. The width of the bed is variable, four to five feet, determined by the reach of the gardener. It is important to be able to reach the center from either side. Length is totally arbitrary and dependent on overall garden layout.



To prepare a raised bed, begin by opening a trench about two spades wide (12") and one spade deep (14") at one end of the bed. The best tool for this is a D-handle garden spade. The soil removed from the spit (i.e. trench) is piled temporarily at the end of the bed, in a wheelbarrow if you like. The subsoil in the trench is then worked with a heavy fork, leaving large clods in the bottom of the trench, which promote excellent drainage. The next step is to dig beneath the topsoil and "slide" it forward with a spade, keeping the topsoil on the surface and the subsoil underneath. Maintaining soil stratification through "slide-digging" is desirable because subsoils are usually less rich in organic matter, poorly drained, clayey, and can contain compounds that are detrimental to young plants. As each trench is opened, the subsoil in the bottom is forked in place and left rough. To complete the digging process, fill the last open trench at the end of the bed with the soil from the first trench that was stored.

After the initial rough digging, the bed is tilthed: the surface soil is broken up to create a fine seed bed, which is accomplished with a digging fork. The fork is used in a lifting motion, which brings all the large clods up to the surface from a depth of four to six inches. The clods are then broken up with a gentle side-to-side glancing motion. Fineness of tilth depends on whether the bed is to be directly sown (finer) or transplanted (coarser), and on whether the soil is of clay (finer) or sandy (rougher) texture.

Having achieved the desired tilth, soil amendments such as aged manures, compost, bone meal, etc. are spread evenly over the entire bed surface. Using a fork, these are worked lightly into the soil, from a depth of two to six inches, depending on the crop being grown. It is important that they be in close proximity to the feeding roots of the specific crop, but shielded from the oxidation of the sun and air at the surface. Remember that nutrients are leached downward with time and watering.

Thus the raised bed becomes a nurturing ground that is literally teeming with life, and which contains all the necessities for germination, growth, flowering and fruiting of the inhabitant plants. Over time, the cultivated bed gives rise to a mini-greenhouse environment above the surface of the soil. As the closely spaced seedlings grow, they provide a dense plant cover which shades and protects the open surface soil from crusting and closing off air and water. The plants also prevent oxidation of surface nutrients and evaporation of moisture. Cooling in summer and buffering against the cold and wind of winter, this sheltered, contained yet permeable micro-climate protects and moderates the vulnerable zone of discontinuity between soil and atmosphere.