

Utilizing Traditional Knowledge in Agriculture

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Abstract

Indian agriculture is at least 10,000 years old. Over millennia, farmers and sages developed innumerable practices to successfully grow crops and raise animals in the highly diversified agro-ecological regions of the Indian subcontinent. Basic principles to grow crops and manage animals were worked out through experience and experimental research. The last 170 years have brought in new techniques, some useful and some harmful.

After the “Green Revolution”, it was realized that high-input agriculture could only benefit about 30% resource-rich farmers, leaving out the remaining 70% resource-poor farmers. If these poor farmers are to raise their living standards, they will need more efficient techniques that will only require locally available, low-cost inputs. I believe our ancient knowledge can help these poor farmers, especially those who depend on rainfall alone.

Over the last 10 years, it has been possible to document traditional practices and to discover “lost” texts on agriculture. We know of many techniques that were used in the past but have been forgotten. There is a great need to validate many of these potentially useful techniques through research.

The paper includes examples of techniques that need to be validated and discusses ways of carrying out the validation.

Indian agriculture is at least 10,000 years old. We know this because by the time the *Rigveda* (c. 8000 BC) was compiled, basic farm operations, as practiced today, had been worked out. Animals were domesticated and utilized for various purposes. New crops and the agronomic knowledge associated with them were being added to farming over the millennia. Today, India grows a very large number of crops because of the availability of diverse agro-ecological conditions. All through this period, until the advent of “modern” agriculture in the last two centuries, farmers themselves, with advice from sages, developed and fine-tuned crop production technologies. Almost all farm activities were based on the local availability of material and human resources. In other words, there was hardly any need to “purchase” external inputs.

During British rule, India’s agriculture suffered a lot because of insecurity, interference with land ownership systems and emphasis on Europeanizing Indian agriculture. Farmers carried on their own traditional agriculture only halfheartedly. When India became independent, its food security was minimal. This led to regular annual import of food.

Though the Green Revolution is criticized today by many people, I must state that it was absolutely necessary to increase agricultural production. Food security is a basic prerequisite for the self-respect of any country. Since the Green Revolution was based on high-input, intensive agriculture, we ran into problems such as the erosion of resources and also the neglect of resource-poor farmers. If the resource-poor farmers are to raise their living standards, they will need to learn highly efficient techniques that depend on locally available, low-cost inputs. I believe the knowledge that we

gained in ancient and medieval periods can help resource-poor farmers today, especially those who depend on rainfall alone as source of water.

We must give credit to George Watt, a British botanist, who included a compilation of traditional agricultural techniques in his multi-volume Economic Products of India, published between 1889 and 1893. From his books, we can get a glimpse of the practices followed by farmers of the Indian subcontinent in the 19th century.

After a long gap, interest in documenting traditional agricultural practices rose as the ill effects of the Green Revolution became evident. The Indian Council of Agriculture recently documented currently used traditional practices.

Over the last 10 years, the Asian Agri-History Foundation, Secunderabad has published English translations of one Kannada (*Lokopakara*, 1025 AD), one Persian (*Nuskeba Dar Fanni-Falabat*, c. 1650) and four Sanskrit (Surapala's *Vrکشayurveda*, c.1000 AD; *Krishhi-Parashara*, c. 400 BC; *Kashyapiyakerishisukti*, c. 800 AD and *Vishnavallabha*, 1577 AD) texts. We now know many ancient and medieval techniques that had been forgotten.

While we have a good knowledge of the traditional agricultural practices followed by resource-poor farmers, we have very few research institutions willing to carry out validation research involving traditional techniques. The national agricultural research system (the Indian Council of Agricultural Research, agricultural universities and others) by and large has focused its attention on agri-business, i.e., on resource-rich farmers. This is very unfortunate!

There are many techniques of traditional agriculture that require validation. Some of these materials and practices need early attention, such as those shown in the table 1 and discussed below.

Table 1. Materials recommended by Surapala to control tree disorders, and their currently known properties

Materials	Properties
Plant species	
<i>Acorus calamus</i> L.	Antibacterial
<i>Aegle marmelos</i> (L.) Corr. (<i>panchamula</i>) [†]	Antifungal; antibacterial; nematocidal; anthelmintic
<i>Brassica alba</i> (L.) Rabenh./ <i>Sinapis alba</i> L. (white mustard)	Insect antixenosis; antifungal; acaricidal; nematocidal; glucosinolate sinalbin “anti-insect” and “anti-nematode”; allyl isothiosinolate antifungal
<i>Clerodendrum phlomidis</i> L. f. (<i>panchmula</i>)	Molluscicidal; antifungal; antiviral; antifeedant; leaf (neoclerodane diterpenes) antibacterial, antifungal and molluscicidal. Induces systemically acquired resistance (SAR) against viral diseases acquired resistance (SAR) against viral diseases

[†] *Panchamula* - roots of five plants; the species are indicated

Materials	Properties
Plant species	
<i>Curcuma longa</i> Koenig non L./ <i>C. domestica</i> Val. (turmeric)	Antioxidative curcuminoids; antimicrobial
<i>Embelia ribes</i> Burm. F.	Anthelmintic; antibacterial; insecticidal (embelinbenzoquinone)
<i>Emblia officinalis</i> Gaertn. (<i>triphala</i>) ‡	Anthelmintic with other two species of <i>triphala</i>
<i>Ferula asafoetida</i> L.	Antimicrobial (contains resin 40–60%; volatile oil – 10–17%)
<i>Ficus benghalensis</i> L. (banyan)	Latex with good sealing properties; tannin
<i>Ficus glomerata</i> Roxb.	Latex; bark 14% tannin; some <i>Ficus sp.</i> are antibacterial
<i>Glycyrrhiza glabra</i> L. (liquorice)	Antimicrobial saponins; glycyrrhizin in underground parts
<i>Gmelina arborea</i> L. (<i>panchamula</i>)	Bark and roots contain alkaloids; resinous substances present
<i>Madhuca indica</i> J.F. Gmel. (<i>madhuka</i>)	Oil cake insecticidal and piscicidal; contains saponin (mowrin); flowers antibacterial
<i>Oroxylum indicum</i> (L.) Vent. (<i>panchamula</i>)	Antiseptic; bark contains alkaloids, tannins and glucoside tetuine
<i>Piper nigrum</i> L. (black pepper)	Oleoresin antibacterial/antifungal; alkaloid piperin is insecticidal
<i>Semecarpus anacardium</i> L.f. (<i>bhallataka</i> , marking nut)	Antiseptic; insecticidal; termite repellent; antifungal; antibacterial; fruits anthelmintic
<i>Sesamum indicum</i> L. (sesame)	Insecticidal and repellent; oil synergistic to pyrethrums; antioxidative lignins in seed; 17% protein; 800 mg per 100 g calcium, phosphorus, and potassium; 14% iron (ash) – highest
<i>Solanum indicum</i> L.	Fruits/leaves antifungal/antibacterial; glyco-alkaloid solasonine present
<i>Stereospermum suaveolens</i> DC. (<i>panchamula</i>)	Antifungal; antibacterial; bark also has same properties
<i>Terminalia bellirica</i> (Gaertn.) Roxb. (<i>triphala</i>)	Antimicrobial properties
<i>T. chebula</i> Retz. (<i>triphala</i>)	Anthelmintic properties

‡ *Triphala* - three fruits; dried powder is used in mixture; the species are indicated

Animal products and other materials	
Materials	Properties
Animal fat	Saponification after release of fatty acids; anti-microbial antimicrobial
Ash	Particles hygroscopic; absorb moisture from insect eggs and spores; interfere with insect feeding; ash potassium interacts with surface fats potassium interacts with surface fats
Brick powder	Action similar to that of ash particles except that these particles are inert
Buffalo horn	Contains keratin, a protein that contains 24% cystine, a sulphur-containing amino acid; used for smoking (fumigation) trees
Cow dung	With urine it is antiseptic; rich in bacteria that compete with pathogens; good medium for biocontrol agents; beneficial to <i>Rhizobium</i> and <i>Azobacter</i>
Cow horn	Same as buffalo horn
Crab shells	Rich source of chitin from which chitosan, a polymer, is made; induces systemic resistance in plants; used in smoking tree wounds
Fish meal	Rich in protein; releases amino acids including praline
Flesh	Same as fish meal; serves as an excellent medium for bacteria that may antagonize plant pathogens; attached connective tissue rich in proline
Ghee	Same as animal fat
Hemp fibre	Used for making smoke
Hog fat	Same as animal fat
Honey	Antimicrobial; protects wounds in plants/animals; proline present; honey-bee peptide apidaecin is antibacterial
Horse hair	High amounts of keratin; used in fumigation
Liquid manure (kunapa)	Effects would include: healthy crop/tree; crop tolerance to abiotic stresses such as frost, heat etc. as well as to insect pests and diseases; high yields; high quality produce
Lotus mud	Stickiness due to a high viscosity exo-polysaccharide, comparable to xanthan, produced by <i>Azobacter vinelandii</i> present in rhizosphere of rhizomes
Marrow	Fats and blood; rich in phosphorus
Milk	Glutamate, leucine and proline make up 40% of the total amino acids in the milk of all animals; mass rearing of <i>Trichogramma</i> ; sticker-spreader; induces systemic resistance in chilli against leaf-curl
Proline (present in some of the above materials)	Induces systemic resistance in plants; stimulates production of antimicrobial phenolics; high endogenous proline increases contents of cytokins and axons; protects against stresses – salts, drought etc.; proline-rich peptides antimicrobial; an important ingredient of parasitic diets; provides power for insect flight metabolites

Milk and milk products

Milk and ghee have been used for centuries. Even buttermilk was found useful. Glutamate, leucine and proline make up about 40% of the total amino acids in milk. Milk is reported to contain plant growth promoters. A recent report (Arun Kumar *et al.*, 2002) claimed that spraying with milk induced systemically acquired resistance (SAR) in chilli against leaf-curl, a viral disease. Milk (10% aqueous suspension) has also been used effectively for controlling powdery mildews. Besides, milk has excellent sticker-spreader properties.

The amino acid proline has been found to systemically induce resistance in plants. It stimulates production of antimicrobial phenolics. High amounts of endogenous proline increase contents of cytokinins and auxins. Apart from milk, proline is present in the connective tissues of animals including fish. Here is an excellent opportunity for us to rediscover the beneficial effects of milk.

Application of cow dung

Use of cow dung for dressing seeds, plastering cut ends of vegetative propagating units such as sugarcane setts, dressing wounds, sprinkling as a diluted suspension on plants and applying to soil has been indicated since the time of Kautilya (c. 300 BC). Indian farmers continue to use cow dung in various ways, but agricultural scientists have ignored its use except as manure (Nene, 1999).

Briefly speaking, cow dung from the cattle shed is a mixture of dung and urine, generally in a ratio of 3:1. Cow dung consists of crude fibre, crude protein and materials that can be obtained in nitrogen-free extracts and ether extracts. Cellulose along with lignin makes up most of the crude fibre; hemicelluloses and pentosans (polysaccharides based on pentose sugars) are also present. Micronutrients too are present in cow dung. The urine portion of cow dung contains nitrogen, potash and sulphur and traces of phosphorus. The nitrogenous compounds excreted in faecal matter consist in part of undigested or unabsorbed food nitrogen and in part of another fraction called metabolic nitrogen. The metabolic fraction comprises substances originating in the body such as residues of bile and other digestive juices, epithelial cells from the alimentary tract and bacterial residues. In short, faecal residues comprise undigested fibre, debris from sloughed-off intestinal epithelium, some excreted products derived from bile (e.g. pigments), intestinal bacteria and mucus. There are more than 60 species of bacteria and over 100 species of protozoa encountered in the rumen of a cow. A majority of the bacteria are cellulose, hemicellulose and pectin fermenters. The bile constituents are bile salts, acids and pigments. Bile salts confer a hydrophilic coat to otherwise hydrophobic droplets, thus acting as emulsifying agents. No bile salt is supposed to be present in dung because these are reabsorbed through the intestine and are returned to the bile. However, in each such cycle (enterhepatic circulation) involving bile salts, a small part is lost through bacterial degradation in the faeces as dyslysin, which is the slimy material. Bile salts have antiseptic properties. The two chief bile pigments are bilirubin (reddish/golden yellow) and biliverdin (green). It is biliverdin that is chiefly present in herbivorous animals and that gives dung its greenish colour (Nene, 1999).

Thus, when seeds are treated in various ways with cow dung, they get coated (pelleted) with cow dung residue. This residue contains cellulose, hemicelluloses, micronutrients, metabolic nitrogen, epithelial cells from the animal, bile salts and pigments, potash, sulphur, traces of phosphorus and a large number of bacteria, the majority of which are cellulose, hemicellulose and pectin fermenters. The cow dung residue has emulsifying properties. A thin dry layer of cow dung on a seed acts like blotting paper and readily absorbs moisture from the surrounding soil, which is to the advantage of the seed. The presence of bacteria in the residue may antagonize potential pathogens ready to attack the seed. According to Foster *et al.* (1983), since root tip mucilage consists, in part, of complex carbohydrates such as cellulose, hemicelluloses and pectin, bacteria that have the ability to use these carbohydrates might get a competitive advantage. In this context, the bacteria found in cow dung would be most suitable as they have the capacity to utilize cellulose, hemicelluloses and pectin. In other words, these cow dung bacteria can quickly colonize the area around sown seeds and thus compete with potentially pathogenic fungi and bacteria and prevent them from attacking the seeds. It is pertinent to note here that one of the fungi commonly used for biocontrol (*Trichoderma hamatum* (Bonord.) Bain) produces the enzyme cellulase and therefore has good competitive saprophytic abilities. If cow dung bacteria possess the ability to produce siderophores (low molecular weight, high affinity iron (III) chelators) and/or the ability to induce systemic disease resistance (van Loon *et al.*, 1998), they could very effectively protect seeds from pathogens. As the use of cow dung for treating seeds has continued for millennia, it is obvious that Indian farmers are convinced of its utility. Many present-day agricultural scientists, who have no experience of living in rural areas, may be “averse” to the idea of doing research on cow dung. However, true, dedicated scientists will not hesitate to take up the work, as there is a lot to learn about the role of cow dung in maintaining seed health. Cow dung on seeds must play a role in the biocontrol of potential pathogens; we just need to scientifically investigate it. This should attract the attention of scientists interested in biological control. If dressing seeds with cow dung is found to be effective in ensuring good germination and emergence in field conditions, existing seed processing plants could use a cow dung slurry or dried cow dung dust to treat seeds on a large scale. Dried cow dung powder could be applied to soil to promote biocontrol. It is gratifying to note that Khanuja *et al.* (2003) have identified a crystalline “cow urine distillate fraction” that enhances the activity of antimicrobial agents (US patent no. 6,410,059). Chakrapani Mishra (Sadhale, 2004) in *Vishnavallabha* (1577 AD) recommends using extracts of cow urine in herbal insecticides, which makes sense in the light of the findings of Khanuja *et al.* Also, farmyard manure has recently been used for mass multiplication of *Trichoderma harzianum* and *Pseudomonas fluorescens* (personal communication – N.W. Zaidi and U.S. Singh).

Liquid manure (*kunapajala*)

Preparation of *kunapajala*, or liquid manure, involves boiling the flesh, fat and marrow of animals such as deer, pigs, fish, sheep or goats in water, placing the boiled matter in an earthen pot and adding milk; the powders of sesame oil cake; black gram boiled in honey; a decoction of pulses; ghee and hot water. There is no fixed proportion for the ingredients. The pot should be put in a warm place for two weeks. The resultant

fermented liquid is a manure called *kunapajala*. Research is needed to standardize and test this manure in orchards.

All the materials need detailed research so that we can provide acceptable scientific evidence to support the recommendations made by Surapala. In fact, we might find opportunities to simplify the procedures. We might also have opportunities to patent the use of some of the materials and procedures.

It is well known that manure from animal wastes is better for plants than the composts made from plant residues. With plant-based composts, there is always a danger of passing on dormant pathogens to fields. There should be no such danger with the application of *kunapajala*. Also, animal wastes are likely to have microflora that might provide better biocontrol of plant pathogens and diseases than plant-based composts.

It is worth pointing that Firminger (1864) who was a “Chaplain of the Bengal Establishment” mentions in his manual of gardening the beneficial use of a “liquid manure”, prepared the way *kunapajala* was prepared, for vegetable cultivation. He has, however, given no information about who first thought of “liquid manure”.

There are many other areas of possible research. Opportunities are waiting for young researchers.

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