The science behind tradition

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Tradition is a term intimately associated with biodiversity. Traditional varieties, traditional practices of cultivation and traditional environment are examples in support. Tribal people consist of 8.4% of India's total population (1991 census). Tribal habitats are biodiversity-rich, but tribal farmers are resource-poor. Conceptually, tradition and science are two intersecting spheres that overlap on principles. The intersection is conceived to represent reality. Tribal cultivation exhibits some traditional practices with an underlying scientific basis. At the same time, there are traditions of scientific concern needing appropriate modification. Rice cultivation in the Jeypore tract of Orissa provides an example and a case that has been studied in depth. This paper presents a possible synergy between tradition and science and argues that participatory research with poor (tribal) and unreached farmers provides an option to ensure sustainable and improved livelihood to them. Unlike high-yielding varieties technology, this option helps to preserve biodiversity-rich habitats, prevents urban migration and promotes in situ on-farm conservation of biodiversity through its sustainable use.

'TRADITION' is a term of central importance in the context of biodiversity. It is acknowledged that tribal farmers in India are gene-rich, but resource-poor. Their invaluable genetic resources, including landraces and local varieties carry novel genes controlling important nutrients, cooking quality and resistance to different biotic stresses.

In fact it has been recorded that such novel genes express high values of the traits governed by them in tribal habitats under the traditional and site-specific cultivation practices in which the genotypes were evolved[1]. However, a survey of tribal areas suggests that there is sufficient scope to fine-tune tribal indigenous knowledge (IK) for optimizing benefits. In this endeavour, scientific knowledge synergized with tradition would have a major role. To facilitate this process, we need to understand the science behind tradition. If so, how do we harness it to multiply benefits? How best can we pyramid traditional and scientific agriculture? We see possible answers in the present paper on the basis of case studies conducted in areas committed to tradition.

Tradition is defined as opinion, belief, custom or knowledge handed down from ancestors to posterity. Equivalently it refers to doctrines supposed to have divine authority, an unwritten law of ancient wisdom propagated by word of mouth. Science is systematic and formulated knowledge. Biological science, which is more relevant to the context of this paper, deals with material phenomena based mainly on experiments/ observations providing authentic, accurate and a verified body of information.

An in-depth view of tradition and science identifies terms like knowledge, information, verified and authority common to the two fields. The intersection of two 'sets' – science and tradition – containing the commonalities represents reality (Figure 1). A few examples from tribal rice-cultivation practices in Jeypore (Table 1) will provide a broad perspective. One would like to strengthen reality, the intersection regime through a congruence of science and tradition. Acknowledged decision processes – inductive and deductive inference – are used to locate the congruence. Inductive inference is led by past experience, for example, ancestral practices, action propagated by word of mouth, strong uncontested beliefs and the initiatives based on them. In a way, it is a tradition-driven decision. In contrast, deductive inference is led by an analysis of organized experiments, evaluation of existing practices, for example, tribal cultivation practices, including varietal selection and seed processing, or new options of screening modern varieties, and scaling up of agronomic practices. Essentially it is a science-driven decision.

India has, according to the 1991 census, a tribal population of 64 million out of a total 761 million at that time (8.4%). Barring the states of Mizoram, Nagaland, Meghalaya and Arunachal Pradesh where the total population is comparatively low but the tribals occupy 64 to 95% of the total, many large states have tribal populations varying from 4 to 22%. Orissa (22% of 32 million), Madhya Pradesh (23% of 66 million),

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Andhra Pradesh (6.3% of 67 million) and Tamil Nadu (1% of 56 million) are some states whose tribals live in areas unreached by government welfare initiatives. But their habitats are biodiversity-rich, while the tribal farmers remain resource-poor. They conserve the diversity as a tradition for no material gain. M.S. Swaminathan Research Foundation is actively involved in improving the lot of such farmers in Jeypore tract of Orissa through a project on conservation and utilization of biodiversity, with the aim of equitable sharing of benefits funded by Swiss Agency for Development and Cooperation. One project activity, participatory plant improvement, is concerned with enlarging benefits from rice cultivation in Jeypore tract, rich in landraces and local varieties, through active and interactive farmer–scientist participatory initiatives. The field experiences in traditionally diverse site villages, separated by long distances, would provide a case study for the theme of the paper.

A survey revealed a number of deficiencies in the cultivation practices of the rice crop. Poor seed quality, planting in ill-prepared soils with high seed rate (50–70 q/ha), consequent uneven stand and crowding of plants leading to early yellowing and poor management of growing crop, with poverty as the root cause, could permit only poor harvests. They did not satisfy even the household requirements. This status of rice cultivation led to the inductive inference that the traditional cultivation practices must be modified on top priority without increasing inputs or cost of cultivation. Therefore experimental trials of formal and farmer practices of cultivation were organized with farmers participating and applying scientific modification of traditional practices in their own fields, as presented in Table 1 (under the column 'Science'). The results amply demonstrated enhanced benefits. Experimental plot yields, both grain and fodder, of farmer-preferred local varieties/landraces increased up to 170% compared to those under traditional methods in 5 villages and 9 sites spread over 2 blocks[2]. The deductive inferences of the experimental results were shared with the farmers who got enthused to switch over from traditional practices to the experimentally proven scientific methods. The higher yields provided the farmers with sufficient stock for consumption through the year, a situation which was rare earlier. Science (new package of practices) synergized with tradition (farmers' preferred landraces/local varieties) to realize enhanced benefits, particularly of grain and fodder yields and thereby household food security.

Though this participatory experiment validated the hypothesis that it is possible to develop a productive synergy between science and tradition, such amended cultivation practices alone cannot sustain a secure and economically sound livelihood security. It only helped to prove that well-conceived and situation-specific scientific interventions can change well-grounded traditions and provide sustainable benefits to unreached farmers. Yet a number of traditional concepts cause scientific concern if continued benefits have to accrue sustainably over time and across the country (Table 2). The

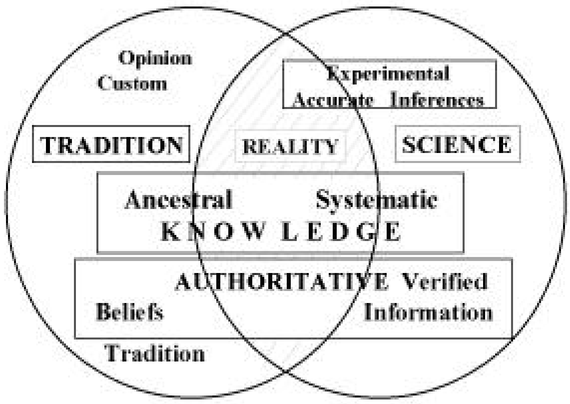

Figure 1. Tradition and science.

Table 1. Tradition, science and reality of some traditional practices of rice cultivation

Tradition	Reality	Science
Organic fertilization	Good for soil health	Will work only with appropriate varieties
Farmyard manure at sowing	Current crop does not benefit	Apply after previous crop in residual moisture or at first showers
†High seed rate (40–70 kg/ha) to ensure plant stand in the wake of deficient moisture, poor seed quality and inadequate soil preparation	Leads to poor crop growth, early yellowing, no tillering, poor yields	Optimize practices: Select seeds (water soak method); Space plant, save seed up to 70%; Timely sowing; Healthy crop growth to better yields
*Beushening, a traditional form of weeding	Principle of survival of fittest; desired seedlings may be lost due to injury	Space planting discourages weed build-up and allows easy weeding
Stacking harvested plants as slanted bundles	Aids air drying, but the process is arduous under traditional planting (see †)	20-cm space between rows ideal for easy stacking of harvested plants

*Beushening is the process of wet ploughing in 15 cm of rain water of 25–35 days crop and laddering with plough to break and loosen soil clods. Two to three ladderings are sufficient to damage and incorporate weeds into the soil.

Table 2. Examples of traditions of scientific concern

Tradition	Science
Strong traditional practices	
Examples in rice	
* Long duration varieties and hence mono-cropping	□ Short duration varieties, and hence multiple cropping
* Photosensitive	□ Photo insensitive
* Planting time during a particular month	□ Planting time decided by weather parameters
* Harvest to match a festive/religious occasion	□ Harvest at physiological maturity
* High reluctance to scale down priority of one trait (e.g. fodder) in favour of another (e.g. grain yield)	□ Easy to develop a variety for grain and another for fodder yield, for example
▲ Twin preferences – traditional food from preferred traditional varieties (consumption priorities) and high yields from modern varieties (economic priorities)	▲ Synergize the twin preferences through genetic reconstruction of traditional varieties at habitats
Low returns of unrefined tradition compounded by poverty-driven vulnerability to resource exploitation	
Concerns of exploitation	
* Compulsive chemical fertilization to grow commercial varieties lowering soil health	□ Organic and bio-fertilization for improved soil profile
* Introduction of HYVs bringing in biotic stresses	□ Traditional varietal selection/breeding, maintaining rich soils
* Impaired expression of potential traits of traditional cultivars	□ Improved expression of potential traits through scientific methods
▲ Fine balance of genotype × environment in biodiversity-rich habitats undergoing gradual disalignment, telling severely on conservation intensity	▲ Sustain and fine-tune genotype × environment balance; implement utilization-driven conservation

most disturbing is the compulsion arising out of poverty to grow high-yielding varieties (HYVs) for economic stability though farmers' consumption priorities are for local varieties and landraces. HYVs could bring in new biotic stresses in the habitats where landraces and local varieties exist free from them. Further, when grown extensively, HYVs would tilt the fine balance between genotypes and environment, essential for specific trait expression. In addition, large areas which would otherwise be allotted to traditional genetic resources would be displaced and grown to HYVs furthering genetic erosion. To discourage this trend, high economic returns have to be provided with local varieties and landraces, and such sustainable use should motivate conservation.

However, tribal genetic resources need a conducive environment to preserve the co-adapted gene arrangements accumulated through long-term selection to retain their specific trait expression[3]. Equally, therefore, tribal habitats need to be nurtured and preserved to save them from environmental imbalance[4].

The lessons to be learnt then from the Jeypore example and the foregoing exposition of quantitative trait expression would be to initiate varietal improvement options only at their habitats (or sites) in order to have an optimal growing environment. Further, in participatory activities at sites, farmers' IK would provide an ideal foil to the formal initiatives to succeed. This is echoed in a recent observation that IK systems should be a step in the new millennium to overtake the current rates of plant extinction and indigenous culture loss[5].

However, doubts prevail on the efficiency of site-specific improvement efforts. For instance, it was observed that such efforts, although important to raising actual yields, are unlikely to raise potential yields. While advocating in that context, optimization of physiological processes, it was emphasized that plants will have to be thoroughly re-engineered to break yield barriers. In the same vein, it was also observed that 'Biotechnology alone cannot achieve this; agronomists tend to view biotechnology as a long shot. Controlling basic multigenic traits is a complex, unpredictable task'[6].

It is true that site-specific participatory plant breeding may not raise yields spectacularly in a short span. But what is important to note is that such programmes pyramid yield on farmer-desired, environment-sensitive traits such as those governing cooking quality and taste. Such improved yields provide for farmers' total consumption requirements and leave extra quantity for commercial disposal. When local markets evolve and get linked, in turn, to bigger regional markets, the farmers generate sufficient income. Their livelihood status improves steadily and gradually. Such paradigms preserve habitats, promote their improvement and encourage farmers to stay there (in constrast to urban migration). Such provisions are essential to favour *in situ* on-farm conservation of site-specific biodiversity (including plants and animals). Unless habitats are preserved and farmers there are provided options to improve and sustain their livelihood, conservation of biodiversity can remain only conceptual. It has been adequately demonstrated that erosion of diversity is a direct function of habitat destruction[7]. If biotechnological improvement is sought, it should not be a substitute to participatory breeding options, but an aid to incorporate specific traits in a site-consonant mode of expression. Farmers are firm that high yields alone are not adequate; they prefer varieties satisfying their taste though not high-yielding. Under such circumstances, modern technologies with emphasis on high yields alone would be inappropriate. It has been further emphasized that participatory varietal improvement initiatives must be supplemented with necessary R&D to produce a better farm technology and maintain it green. Examples include no-till farming, mulch-till farming, integrated nutrient management, rotational grazing (moving livestock to different pastures to reduce the build-up of manure, instead of collecting manure) and organic production[8].

However, the need for relevant basic research and innovative options has to be admitted. An example, in the context of improving varieties by enhancing expression of quantitative traits, is that of characterising G in quantitative terms (a possible approach could be through molecular genomics?) in the model $P = G + E + (G \times E)$, where P, G and E are the phenotype, the genotype and the environment and $(G \times E)$, the genotype–environment interaction. Such basic research needs to be complemented by mission-oriented strategic research at the target areas to accord basic results an application potential. In India, basic research is mostly confined to university-based science departments and some research institutes. Applied and strategic research is done in applied science departments of universities, some private organizations and NGOs. The field extension of the research results is carried out by government extension agencies and to a limited level by NGOs and individual agencies. The resulting benefits to the unreached farmers are additive at best. With an ideological and structural reconstruction, such additive benefits stand a high chance to become multiplicative. Can we then say that revitalizing tradition synergized with science would provide a green framework for improving the lot of poor and unreached farmers?

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Plutonium dispersal and health hazards from nuclear weapon accidents†

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We analyse the dispersal of plutonium into the atmosphere and consequent biological hazards from nuclear weapon accidents. Such accidents involving nuclear weapons could be caused, for example, by missile and jet fuel fires and explosions. We use the wedge model of aerosol dispersal to estimate the amount of plutonium that would be inhaled by a surrounding population and the resulting radiological damage in the form of increased cancer fatalities in the event of such an accident. These considerations are then applied to possible accidents in South Asia and inferences drawn.

IN this article we analyse nuclear weapon accidents that result in the dispersal of plutonium into the atmosphere and its impact on public health. Our motivation for doing so derives from the current situation in the South Asian subcontinent. Both India and Pakistan tested nuclear weapons in May 1998. Although there is no public information on how many weapons each country has or the state of their deployment, the general impression is that neither India nor Pakistan has yet fully deployed its nuclear weapons. But it is possible that this comparatively less dangerous situation may change in

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