The cellulose produced from such a bio-
refinery process is used to make greener
versions of ethanol and plastics. Such a
breakthrough will mean that a farmer
could harvest two crops from every field,
a grain crop and a biomass crop.

Agro wastes can be used as soil
improver/fertilizer. For this, the post-
harvest residue of cotton, castor, sugar-
cane trash, banana stems, etc. can be
chopped in situ and sprayed with a micro-
bial mixture. The consortia of microbes
decompose it and convert it to useful soil
nutrient, and also supply the much needed
organic carbon for which our soils are
hungry. Our chemical fertilizer utilization
efficiency and economics are already
badly affected due to lowering organic
carbon in the soils of most of the states.
Such an emphasis on agro waste use in
farms will also help water-use efficiency.

We therefore need a much greater
emphasis on this aspect as in the long
run, even when we consider the aspects
of sustainability, food will be of greater
priority.

Lastly, though the author1 arrives at
the ‘inevitable conclusion that renewable
energy sources stretched to their full
potential can at best contribute 36.1%
(0.75) of the total need’ (by 2070), we must
not forget the likely breakthroughs which
can change the picture more favourable.
Just two examples:

(i) Microalgae, as distinct from sea-
weed or macro-algae, can potentially
produce 100 times more oil per acre than
soybean or other crops, will be non-
competitive with agriculture and can give
much the needed breakthrough.

(ii) Another big hope will be organic/
polymer solar cells. This is relatively a
novel technology, but holds promise of a
substantial price reduction and faster
return on investment. These cells can be
processed from solution and can be pro-
duced by roll-to-roll printing process,
leading to inexpensive, large-scale
production. With newer materials, their
efficiency can dramatically increase.

Such new developments can hopefully
raise the potential of renewable energy
use more substantially than what is being
predicted as 36%.

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Conservation of chironji and cultivation of off-season rainfed tomato

Sonbhadra District, a part of the Vindhyan
zone, is one of the most backward dis-
tricts of Uttar Pradesh1. Most of the
people in this district belong to tribal
communities/schedule caste. Their major
sources of income are farming and col-
clection and selling of minor forest-based
products (as about 55.73% of the area is
under forest; www.sonbhadra.nic.in). Major
crops are rice and wheat, but due to the
lack of irrigation facilities, agricul-
ture depends entirely on the monsoon
leading to poor productivity of crops.
Collection and selling of minor forest-
based produce, especially chironji (one
of the important multipurpose forest spe-
cies) brings income to the local inhabi-

tants. Chironji (Buchnania lanzan Spreng
syn. B. latifolia Roxb), also known as
char, piyal or achar belongs to the family
Anacardiaceae (Figure 1). It is a sub-
tropical, underutilized/underexploited nut
fruit and is considered to be native to
India. This multipurpose tree provides
food, fuel, fodder, timber and medicine
to the local community. It is a popular
and edible nut fruit, eaten raw or roasted
and also used in making dessert. Its
kernel is rich in fat (59.0 g), protein (63–
72%), starch (12.1%), minerals like cal-
cium (279 mg), phosphorus (528 mg),
iron (8.5 mg) and vitamins like thiamine
(0.69 mg), riboflavin (0.53 mg), niacin
(1.5 mg) and vitamin C (5.0 mg). It also
contains 34–47% oil and provides nutri-
tion to the local inhabitants2. During
summer when green fodder becomes un-
available, local inhabitants use its leaf as
green fodder for their animals, especially
buffalo, goat and sheep. Its dried wood is
utilized as a fuel. The timber of chironji
is slightly resistant to termite and is uti-

ilized for making furniture, boxes and
crates, desks, fine furniture, match boxes,
mill work, moulding, packing cases,
stools, tables and agricultural imple-
ments. Some parts of the plant are also
used to cure diseases, for instance roots
in diarrhoea, leaves for skin diseases and
healing wounds, gum/resins in diarrhoea,
and fruits in asthma and cough. Locals
also earn money by collecting gum/resins
and lac by rearing kussumi strain of lac
on the chironji tree.

At present the plant is grouped as an
underexploited and non-nationalized
minor forest produce. It is free for col-
clection, as a result of which the local in-
habits, traders and greedy merchants
destroy the branches/whole trees during
collection of its fruits without bothering
about new plantations. This has led to the
destruction of chironji plants in the for-
est. There is an urgent need to develop a

Figure 1. Foliage of chironji.
Technology for easy multiplication and regeneration of chironji, and to popularize its importance among local inhabitants/tribals.

Due to seasonal drought in kharif for the last 7–8 years, the farmers of Sonbhadra District have not been able to harvest paddy crop. More than 60% of the farmers depend on paddy. However, erratic, uncertain rainfall and seasonal drought has resulted in poor production of the crop. Due to this and in response to the efforts of the Krishi Vigyan Kendra (KVK) and results of on-farm trails and front line demonstrations conducted by KVK, the farmers have shifted towards tomato cultivation (it was already known that tomato can be cultivated as off-season rainfed crop during kharif under upland condition). In the beginning the local cultivar named Kajala was popular, then Sel-7, Sel-22, DVRT-1, DVRT-2, H-86 and JK desi were popularized. In recent years hybrid varieties like 3585 of Sungrow, 2535 of Namdhari, US-404 of Agriseeds, NP-5005 (Lakshmi) of Nunhems Pro Agro are dominating and yield between 350 and 550 q/ha. At present, more than 12% of the area under paddy cultivation is converted into tomato cultivation. Robertsganj mandi has been established as a big and stable market for the merchants from far-off destinations.

The unique characteristic of this tomato crop is that without any irrigation facilities under upland condition, in sloppy, undulated and hilly tracts under low-land condition, in black cotton and red laterite soils, it is growing well and farmers are getting good returns (Figure 2). On the basis of economics we have observed that after spending Rs 50,000–60,000/ha, one is benefitted with a net return of around Rs 100,000–150,000/ha in a single cropping season. This indicates that the tribals of Sonbhadra district are marching towards self-sustenance with cultivation of off-season tomato. There will be more economic and sustainable growth if proper attention is paid to the conservation of forest resources as a whole and chironji in particular.

**Tricotyledony in Hippophae rhamnoides L. (Elaeagnaceae)**

The phenomenon of typically dicotyledonous plants producing three cotyledons has been referred to as tricotyledony or tricotyly. More generally, the production of an abnormal number of cotyledons has been referred to as pleiocotyly. Molecular studies have shown that a few mutated genes could produce tricotyledonous traits in the model plant, Arabidopsis. Tricotyledonous seedlings occur sporadically in nurseries of dicotyledonous plant species in over 15 families of plants. However, the phenomenon has not been reported in seabuckthorn (Elaeagnaceae).

The actinomorphic plant seabuckthorn (Hippophae rhamnoides L., Elaeagnaceae) is dioecious and wind pollinated. Seabuckthorn berries are among the most nutritious of all fruits and have immense medicinal properties. Seabuckthorn is mentioned in the writings of ancient Greek scholars such as Theophrastus and Dioscorides. The medicinal value of seabuckthorn was recorded as early as the 8th century in the Tibetan medicinal classic Gyud Bzi (Four Text of Fundamental Tibetan Medicine). The shrub serves as a storehouse for researchers in the field of biotechnology, nutraceutical, pharmaceutical, cosmetic and environmental sciences.

During our study in 2009 to check seed viability of a 10-year-old seabuckthorn seed stock, we observed few seedlings with three cotyledon leaves. To check the frequency of tricotyledony in seabuckthorn, seeds from 30 different plants maintained in field gene bank (lat. 34°08.2’N, long. 77°34.5’E, altitude 3340 m amsl) at the Defence Institute of High Altitude Research, Leh-Ladakh were collected in 2010. Seedlings were raised in pots and emergence of cotyledon number was checked on each plant approximately every 3 days. Plants were scored in three categories: two full cotyledons, three full cotyledons and greater than three cotyledons. Tricotyledonous seedlings were transplanted into the greenhouse.

The observed tricotyledon frequencies among the 2798 germinated seedlings from 30 plants ranged from 0% to 6.4%, with an average of 0.64%. A rare single tetracotyledon seedling was also observed. Low frequency of tricotyledony has also been reported in Brassica oleracea var. capitata (0.6%) and Crotolaria juncia.