# Chicory – a case of weed into forage crop transition

Egyptian clover or berseem (*Trifolium alexandrianum* L.), probably the earliest forage crop grown since 3800 BC in Egypt, was introduced into India in 1904, and has been widely adopted since 1916 as a winter season fodder crop in the country[1]. Various research institutions under the ICAR have played an important role in evolving high-yielding fodder varieties. The northwest and central zones of India are by far the most efficient zones for intensive fodder production. The berseem–hybrid Napier–cowpea sequence produced maximum forage and economic returns per rupee investment[2].

Chicory (*Cichorium intybus* L., Asteraceae) is found as a dominant weed of berseem fodder fields, with an equal capacity to regenerate its vegetative shoots along with berseem after subsequent cuts. As the sowing and flowering time of chicory also coincides with that of berseem, generally the market seed samples of berseem contain chicory seeds as an adulterant. Chicory is also a major weed in other rabi-season crops like chickpea, summer green gram and French beans, reducing the yields considerably. Although chicory is an established and dominant weed in berseem crop fields in India, quantitative data on the extent of suppression of yield to the main crop are yet to be estimated. Forage potential of berseem crop is high, and can produce 1000–1200 q/ha of green fodder under improved agronomic management practices. However, the average yields are reported to be 175 q/ha in the first cut, 225 q/ha in the second and third cuts, 175 q/ha in the fourth cut, 125 q/ha in the fifth cut, and 75 q/ha in the sixth cut[3].

Fodder crop agronomic survey of some selected villages in six Tehsils of Agra District was conducted during the rabi season. This brought to light the practice of various sowing proportions of berseem and chicory seed mixtures, ranging from instances where chicory not only dominated the berseem fields (reducing berseem yields), but also sometimes becoming the exclusive choice of marginal farmers for fodder production, the reason being that berseem performed poorly in a specific location or utilizing wasteland courtyards of villagers with small holdings[4]. On the contrary, farmers with large holdings in the neighbourhood of the Dayalbagh Educational Institute (DEI), Agra, earmarked considerable man-days for sorting out chicory plants from those of berseem at the time of final cut for seed harvest, so that the subsequent crop will have minimum contamination of chicory in the field. The survey results indicated further that berseem and chicory do not compete for insect pollinators. On the other hand, together they help in enhancing the pollinator biodiversity in the field. Chicory seed yield did not suffer from under-pollination, whereas for berseem accommodating beehive boxes in the field was necessary to achieve higher and better quality seed-yield and also generating supplementary income to farmers through honey production[5]. Due to diversity in ecological conditions and bee-flora, the Indo-Gangetic plains is distinguished as a separate region based on bee-management pattern. Even though cultivated crops constitute a large part of the bee-flora, arboreal taxa also contribute significantly towards honey production. The status of bee-keeping in Uttar Pradesh has been reviewed by Yogeshwar Singh[6]. The biggest honey yields recorded per season for *Apis dorsata*, *A. cerana indica* and *A. florae* were 25–100 kg, 10–40 kg and 166 g–1 kg respectively. A minimum of 50 million bee colonies are required for meeting the demands of bee-dependent crops in India. During the 1980s, an estimated one million beehives were functioning under various schemes of the Khadi and Village Industries Commission. India has the potential to keep about 120 million bee colonies that can provide self-employment to over 6 million rural and tribal families. In terms of production, the bee colonies can produce over 12 million tonnes of honey and about 15,000 tonnes of beeswax[7].

Chicory is grown as a leaf vegetable 'Witloof' or salad green in Europe, and as a fructose crop in many parts of the world. Its roots are often used as a coffee substitute or supplement, particularly in India and South Africa, where more than 90% of all the coffee consumed contains chicory. It is used as a component in liver tonics.

However, research studies conducted over the past 25 years in New Zealand, Australia, United States and Canada have thoroughly evaluated its potential as a forage crop in terms of the agronomic characteristics, herbage production, grazing management, nutritive value, animal performance of forage chicory, as well as the problems encountered when incorporating forage chicory into the farming system. An improved forage chicory cultivar, 'Grassland Puna' was commercially available in 1985 in New Zealand, after ten years of selection. Chicory is emerging as a forage crop with its higher organic matter digestibility, voluntary feed intake. It meets or exceeds the recommended dietary minerals requirements of lactating dairy cows, beef cattle, sheep and red deer than grass-based pastures during spring, summer and autumn. It has a good growth potential on low-fertility soil, tolerance for a wide range of pH (4.8–6.5) and ability to produce high-quality forage on acid soils[8].

Researchers from many parts of the world recommended a combination of chicory with either a legume (chicory + white clover) or a grass (*Phalaris* + chicory), as the milk from dairy cows fed with only chicory diet was found to have a bitter taint due to its high level of sesqueterpene lactones[8].

The Department of Agriculture, Pennsylvania, USA, which listed chicory as a noxious weed until 1993, made an exception to allow its use as a forage crop. Taking cognizance of the international research developments on chicory weed emerging into a forage crop, it is worthwhile to probe into its prospects in the Indian context[2,9]. Chicory is not yet cultivated as a fodder crop in India. Any such exercise may, probably, need to keep the following criteria in the forefront: (1) The landless and marginal farmers, who constitute 58% of the rural population sustain themselves through 481 million livestock, which serve as the most critical components of our rural production system. (2) The present feed and fodder resources in the country can meet only 46.6% of the requirement. (3) In spite of poor infrastructure, low investments and low priority shown to this sector, livestock has provided sustainability and stability to agricultural production. (4) Contribution of livestock to agricultural gross domestic product has increased from 14% in 1980–81 to 26% in 2000–02 (post green revolution period). (5) Only 6.9 mha or 4.4% of the country's cropped area is under fodder crops and there is hardly any scope of expansion because of pressure on agricultural land for food and cash crops. (6) The solution, therefore, lies in maximizing forage production in space and time, identifying new forage resources, increasing forage production within the existing farming systems, utilizing marginal and sub-marginal dry lands and problem soils for developing feed and fodder resources. (7) The monsoonal grasslands of India are also impoverished, overgrazed and infested with bushes. (8) *Phalaris* is a noxious weed in the wheat fields of India as chicory is in legume crop fields, and both should be kept out of our prime irrigated cropping systems.

In the Indian context, fodder chicory cultivation is not feasible to be taken up under the farming systems, as it continues to be an obnoxious weed. However, it is recommended for introduction and cultivation in national parks, sanctuaries, etc. where along with grasses, it may constitute a nutritive fodder for wild animals and forage for the declining population of insect pollinators.


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# Soil aggregation by vermicompost of press mud

Investigations were made to recycle agro-industrial wastes for the production of vermicompost using earthworm, *Eudrilus eugeniae* and bacterial inoculum (with viable count $168 \times 10^9$/g/ml) at laboratory scale. The vermicompost obtained was studied in a petri plate system for aggregation of soil. One gram of vermicompost derived from press mud using *E. eugenae* and bacterial inoculum was found to retain 74.10% on 90 μm sieve, indicating that 20 g of 90 μm soil is bound by the vermicompost. This property of vermicompost appears to have potential use for soil erosion-control measures, acting as a micro dam which holds water.

Soil aggregation plays an important role in the soil–air ecosystem and provides the bases for the life-supporting system of micro flora and fauna. (The weathering cycle of formation of soils and rocks gives rise to solid rock formation and vice versa, i.e. soil formation due to physical agencies like wind, air, water, climatic changes, etc.) The soil formed has to be maintained on a long-term basis and this is the role of microbes to hold together the soil solids. The present-day barren and waste lands need to be looked upon by researchers as a challenge to recover the lost flora and fauna by reducing soil erosion. Therefore, an experiment on vermicompost is presented specially with reference to soil aggregation property, which brings a correlation between vermicompost soil and the microorganisms.

The vermicompost of press mud (1 g) using *E. eugenae* and bacterial inoculum with viable count $168 \times 10^9$/g/ml was used in the experiment.

One gram of this vermicompost was placed in a petri dish. Using a sterilized, straight wire, the vermicompost was spread all around aseptically as shown in Figure 1 *a*. Next 20 g of industry soil passed through 90 μ sieve was spread above the vermicompost as shown in Figure 1 *b*. The plates were observed at every 2 h interval. The plates shown in Figure 1 *a* and *b* taken after 10 h are shown in vertical and inverted positions.

Sieve analysis was carried out according to the standard procedure[1] using IS sieves. Figure 1 *c* and Figure 2 show the cohesive nature of forces brought about by inoculating 1 g of vermicompost by virtue of their positions, whereas Figure 1 *a* and *b* show stable casts and soil poured on the casts. The soil was firmly held in a vertical position; and an inverted position indicates that microbes present in the vermicompost and their water-holding capacity are responsible for the formation of stable aggregation. The formation of aggregation of soil also reduces soil erosion in the field. The water-holding capacity which was above 100%, an important property of vermicompost due to its amorphous nature, can be utilized during drought conditions as mini reservoirs or micro dam. This will allow maintaining the health of the soil for longer periods. Microbes in 1 g of vermicompost with cfu $100 \times 10^9$/ml/g can hold 20 g of soil in position. Water from the vermicompost is released when dry conditions prevail in the environment. The microbes identified as sporulating bacilli can survive in adverse conditions. When the moisture levels in the soil are regained during the rainy season, microbes