they are published (sic). Slack picks the top "fashion journals" in biology as Cell, Nature and Science, which have high impact factors. Yet the impact factor is determined not by the bulk of the papers in the journal, but by a few heavily cited ones. Thus, most of what the fashion journals contain is actually the same sort of thing the specialist journals carry but dotted up to look a bit special. Slack's [own] papers published in specialized journals were just as good as those he published in the fashion journals, both in his opinion and as measured by the citations they attracted. Lawrence also states that 'in a creative industry like research, where real discoveries are always published in journals which measure the number of their time, these measures [such as the impact factor] are at best crude'.

The second article I wish to cite is a commentary by Graham Walker, editor-in-chief of the Journal of Bacteriology and I quote some excerpts: "It is strikingly obvious how easily one's editorial decisions to favor only fast-moving areas of research . . . could greatly increase a journal's impact factor . . . [On the other hand, we publish truly the best papers in the field but do not bias our decisions by considering the perceived popularity of the topic . . . . The enduring legacy of this editorial tradition has been the publication of important papers that continue to generate citations for many years'. Walker then provides data which show that: (i) approximately 2200 articles published in Journal of Bacteriology in 1995 and 1996 garnered 7700 citations in 1997, for an impact factor of 3.5; (ii) these 7700 citations represent only 17% of the citations in 1997 to all papers published in the journal, with the remaining 83% (which one may call the 'forgotten citations') citings published in 1994 and the years preceding; and (iii) there were, respectively, around 2000 and 2400 citations in 1997 to the 900 papers published in 1988 and the 1000 in 1989, for an 'endurance impact factor' (my own jargon) of 2.3. So then, should we say that there are the hares as well as the tortoises among the different journals?

In our country, some scientometricists and science administrators have gone one step beyond the impact factor to employ derivatives, such as average impact factor per paper published (which in my opinion is nonsensical), to compare the research outputs of different institutions. One wonders whether to such a science establishment (as Lawrence puts it), 'the real purpose of the endeavours becomes forgotten and it devotes itself, not to making the important measurable, but to making the measurable important'.


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SCIENTIFIC CORRESPONDENCE

A potential biocontrol agent for pigeonpea cyst nematode (Heterodera cajani Koshy)

Cyst nematodes are soil-borne plant pathogens capable of causing destructive plant diseases. These plant pathogens produce survival structures called cysts (Figure 1 a), which are actually dead females. The females upon laying their eggs gradually undergo morphological changes and become protective cases for the eggs. Cysts remain viable for many years in the soil. Thus, once introduced in a cultivable area, it is difficult to eradicate them, the best example being that of potato golden cyst nematode which since it was spotted in the Nilgiris, Tamil Nadu in 1961 (ref. 1) still remains a major constraint to the cultivation of potato3.

Pigeonpea cyst nematode, Heterodera cajani was first reported on pigeonpea (Cajanus cajan (L) Mill.) from India in 1967 by Koshy and was earlier described as H. trifolii2. Apart from pigeonpea, it has a vast host range including many other legumes, viz. greengram, blackgram, moth bean, cowpea and an oilseed crop sesamum. The second stage juveniles upon emergence from the eggs infect the host plant root system through their stylets. The root system initially shows white females which upon death become brown cysts containing eggs and juveniles. The plant gradually loses its vigour, grows poorly and yields less depending upon the initial nematode density. The yield reductions have been reported to be up to as high as 80% (ref. 4). The pathogen is fast becoming a serious threat to pigeonpea.

The cysts are highly resistant to pesticides and tolerate adverse edaphic factors. With research efforts to get host plant resistance remaining scarce, biological control techniques offer a good option in the management strategy against H. cajani. Biocontrol agents in addition to being cheap and effective are the safest in terms of environmental considerations and warrant relatively less technical skill for their application. Walla et al.5 reported an actinomycete Paecilomycetes penetrans infecting second stage juveniles of H. cajani. P. penetrans is an obligate parasite and is not culturable on synthetic growth media. Methods to mass multiply P. penetrans have been fraught with difficulties. Thus with the above considerations in mind, a study was undertaken to isolate native antagonistic fungi from the field soils since natural enemies will be effective in combating this nematode. Earlier reports indicate that egg parasitic fungi are more effective against soybean cyst nematode6. Hence, the study was confined to the isolation of fungal endoparasites of cysts and eggs.

Field soils from Gulbarga district, Karnataka, where pigeonpea monocropping is practised were processed for cysts of H. cajani as per the standard sieving and decanting procedure of Cobb7. Cysts were then surface sterilized with 1% sodium hypochlorite solution and placed on potato dextrose agar (PDA) medium in petriplates aseptically. The plates were incubated for three days at room temperature and then observed for

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growth of the fungi, if any, from the cysts. Five species of fungi were isolated, viz. Aspergillus nidulans, Penicillium sp., Fusarium sp., Cladosporium sp. (Figure 1 b) and Botryodiplodia sp. While the former three were identified in the laboratory itself, Cladosporium sp. and Botryodiplodia sp. were subcultured on PDA slants and sent to Agharkar Research Institute, Pune, India for identification of the species. They were identified as *C. herbarum* and *B. theobromae*, respectively. This constitutes the first report of *C. herbarum* and *B. theobromae* parasitizing the cysts of *H. cajani*.

Because of their relatively higher frequency of occurrence on the cysts, only *C. herbarum* and *B. theobromae* were retained for further studies. These two were further compared to determine the more efficient one. Twenty-five surface sterilized cysts were placed on these two fungal culture mats separately on 2% water agar medium in the petriplates. The plates were incubated at room temperature and observations for the cyst parasitization by these two fungi were taken at an interval of 24 h and results compared. The results (Table 1) indicated that *C. herbarum* was more rapid in parasitizing the cysts of *H. cajani* by parasitizing 97% of the cysts in 96 h while *B. theobromae* parasitized only 49% of the cysts in the same time.

It was noted that young cysts were more prone to infection by *C. herbarum* than matured cysts. Upon infection, the cyst walls became fragile and the cyst colour changed from brown to black. On some matured infected cysts, fungal mycelium was seen on the cyst wall, but the young cyst walls did not have any such growth on them. This observation suggests that some nematotoxic may be involved in the parasitization process. Similar observations on cysts of potato golden nematode, *Globodera rostochiensis* have been made by Krishna Prasad and Singh. Eggs inside the infected cysts exhibited a range of denaturation, i.e. from complete to partial destruction of the juveniles inside the eggs (Figure 1 c). Refractive droplets inside the eggs (Figure 1 d), which indicate a microbial attack on the deve-

<table>
<thead>
<tr>
<th>Time (h)</th>
<th><em>C. herbarum</em></th>
<th><em>B. theobromae</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>26.30 (30.87)</td>
<td>03.20 (10.21)</td>
</tr>
<tr>
<td>48</td>
<td>44.10 (41.50)</td>
<td>10.00 (18.28)</td>
</tr>
<tr>
<td>72</td>
<td>76.00 (60.70)</td>
<td>25.80 (30.55)</td>
</tr>
<tr>
<td>96</td>
<td>97.00 (79.73)</td>
<td>49.00 (43.72)</td>
</tr>
</tbody>
</table>

*Mean of five replications.

Figures in the parentheses are the arcsin percentage transformation values.
loping juveniles were noticed on all infected cysts and eggs.

Thus, *C. herbarum* offers a great potential to pigeonpea growers in the management of pigeonpea cyst nematode. Further studies on the development of a formulation using this biocontrol agent for delivery into the soil are under progress in our laboratory.


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Oxygen (\(^{18}\text{O}\)) isotopic enrichment in the leaves as a potential surrogate for transpiration and stomatal conductance

Water is perhaps the most important constraint that limits productivity under tropical conditions. Among a number of adaptive strategies developed by plants, water use efficiency (WUE), ratio of the amount of biomass produced over a period of time to the total water transpired during the same period) is most noteworthy.

Increase in WUE is normally achieved through a reduction in transpiration rate (*T*). Due to the direct relationship between *T* and biomass production, selection for high WUE often accompanied a reduction in total biomass. This interdependency seems to be the major reason for the lack of success in breeding for increased WUE.

In genotypes where the interdependency between *T* and WUE is weak, selection for high WUE would not accompany a reduction in biomass. Therefore, it is essential to measure the variability in both *T* and WUE. While the genetic variability in WUE can be determined by the carbon isotope discrimination technique (\(\Delta^{13}\text{C}\)), no such measure of *T* integrated over time average is available. This necessitates the development of a suitable technique to measure *T* on a time-integrated basis.

Stable oxygen isotopes have generated considerable interest in plant carbon and water relations in recent years. Water vapour molecules containing the lighter isotope of oxygen (\(^{16}\text{O}\)) diffuse relatively faster than do molecules with the heavier isotope (\(^{18}\text{O}\)), so that during evaporation, water gets enriched with the heavy isotope molecules. Further, the isotopic enrichment occurs during evaporation also, because the vapour pressures of \(^{16}\text{O}\) water is lower compared to that of the \(^{18}\text{O}\) water.

In this paper, we demonstrate that this feature can be utilized to measure the rate of transpiration and stomatal conductance (\(g_s\)) in plants.

Seven genotypes of cowpea significantly differing in *T* (based on our previous experiments) were selected and raised in battery containers. The mean transpiration rate was determined by gravimetric approach standardized at our center. Stomatal conductance (\(g_s\)) was measured by gas exchange methods on the fully expanded top leaves of these genotypes.

Leaf water from fully expanded leaves was collected by freezing (liquid nitrogen) and thawing (boiling water bath) 50 leaf punches (1 cm\(^2\)) in sealed plastic tubes. The tubes were purged with dinitrogen to remove the air inside and all extraction work was carried out in this condition only. Later leaf water was drawn after centrifuging the tubes using a syringe. \(^{18}\text{O}\) composition of the leaf water was determined (in 500 \(\mu\)l of water) by direct equilibration with CO\(_2\) in specific vacutainer tubes using an isotope ratio mass spectrometer (IRMS).

The stomatal conductance showed a strong positive correlation with \(^{18}\text{O}\) composition of leaf water suggesting that

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**Figure 1.** Relationship between stomatal conductance (\(g_s\)) and \(^{18}\text{O}\) enrichment in leaf water in six contrasting cowpea genotypes. The \(g_s\) was determined using a portable photosynthesis system on the top of a fully expanded leaf (light intensity > 1500 \(\text{mmol m}^{-2} \text{s}^{-1}\)). Each value is an average of at least three replicates.