Received: 17 November 2024 | Revised: 1 February 2025 | Accepted: 5 February 2025

DOI: 10.1002/jsf2.70001

RESEARCH ARTICLE

JSFA Reports

Analysis of plant science higher education reveals mixed provision which falls short of delivering national priorities

Sarah Trinder[1,2] | Thomas Heaven[3,4,5] | Matteo Luberti[4,5,6] | Sophie Read[2,4,5,6] | Adam Scanlon[5,7] | Chris Gauntner[5,8] | Alec Forsyth[2,7] | Alison C. Foster[2,9]

[1]UK Vegetable Genebank, School of Life Sciences, University of Warwick, Coventry, UK

[2]SCI Horticulture Group, London, UK

[3]School of Natural Sciences, University of Lincoln, Lincoln, UK

[4]Department of Genetics, Genomics and Breeding, NIAB-EMR, East Malling, UK

[5]Working as Intern for SCI Horticulture Group, London, UK

[6]School of Agriculture, Policy and Development, University of Reading, Reading, UK

[7]Section of Natural and Applied Sciences, Canterbury Christ Church University, Canterbury, UK

[8]School of Biological and Medical Sciences, Oxford Brookes University, Oxford, UK

[9]Centre for Biocultural Diversity, University of Kent, Canterbury, UK

Correspondence
Alec Forsyth, SCI Horticulture Group, London, UK.
Email: alec.forsyth@canterbury.ac.uk

Funding information
Society of Chemical Industry

Abstract

Background: Many reports from the UK government and other organisations highlight a need for a plant aware workforce, and some enumerate specific areas of plant science where there is a skills shortage. We have undertaken a systematic analysis of the content of degree programmes that advertise as teaching plant biology to determine if the UK Higher Education (HE) sector is delivering the graduates required to meet the skills gaps reported.

Results: Our data reveals a highly mixed picture of delivery from 1- to 4-year courses, modules ranging from 10 to 40 credits, and Higher Education Institutions (HEIs) providing variable information on their websites. Our analysis shows that on average (irrespective of credit) a module covers three subject areas. Most courses have little plant content and it is generally taught with other subjects on a module. The most substantial plant-specific subject teaching is delivered on 18 courses we have identified as Plant Science courses.

Conclusion: Overall, the UK HE sector is not delivering graduates with the skill set outlined in numerous reports as required to enable food production in a changing climate. Any prospective student (or employer) will find it virtually impossible to determine which degree will deliver the skills they need as there is no plant curriculum offered across the board, and specific information is hidden within module descriptors on websites. If the skills outlined as being essential for the economy and society are truly important, then a new approach is required.

KEYWORDS
botany, curriculum analysis, gap analysis, horticulture, plant science

INTRODUCTION

Plants are vital to life on earth and yet so often they are relegated to being merely a uniform green backdrop for organisms perceived as more interesting or exciting. This phenomenon of over-looking the value of plants has been well documented, and was initially termed 'plant blindness',[1,2] but has now become known by the more inclusive term Plant Awareness Disparity (PAD).[3] The prevalence of PAD is of particular concern in educational settings. Work is being undertaken to understand why it exists[4] and also to develop a PAD index so that

Thomas Heaven, Matteo Luberti and Sophie Read contributed equally to the study.

educators (and others) can understand their own levels of plant awareness so that their teaching is not unintentionally biased against plants.[5] Some examples of research aiming to quantify the levels of PAD within education settings includes the work of Ahi *et al.*[6] in Turkey, analysing PAD in Turkish textbooks and the work of Brownlee *et al.*[7] in the United States looking at PAD within introductory Biology textbook images used in undergraduate courses.

Globally, plants have a central role to play in achieving many of the 17 UN Sustainable Development Goals (SDGs),[8] although there are concerns that progress towards achieving these goals is being impeded by PAD.[9] A 'plant aware' workforce, trained and educated about plants at Higher Education (HE) level, will be critical to implementing the SDGs of Zero Hunger, Good Health and Well-being, Clean Water and Sanitation, Affordable and Clean Energy, Climate Action, Life on Land and more. To achieve this 'plant aware' workforce, suitable education and training must be available.

In a UK context, there are serious concerns that a plant aware workforce does not exist. This is evidenced by reports produced by government, learned societies and industry bodies, throughout the past decade, highlighting that skills shortages are arising across plant-related industry sectors including ornamental horticulture, horticultural (edible) crop production and plant science research.

The Global Food and Farming Futures Project, led by Sir John Beddington culminated in a Final Report entitled 'Foresight. The Future of Food and Farming'[10] detailing how the global food system is consuming the world's natural resources at an unsustainable rate. It highlighted the importance of education in achieving the necessary goals:

> Scientific and technological advances in soil science, relatively neglected in recent years, offer the prospect for a better understanding of constraints to crop production and better management of soils to preserve their ecosystem functions, improve and stabilise output, reduce pollutant run-off and cut greenhouse gas emissions.[10]

The detrimental impact of skills shortages in particular subject areas was also cited: 'The long-established disciplines of agronomy, soil science and animal husbandry need revitalising and expanding to address the integration of sustainability into agricultural systems much more explicitly'.[10]

The Royal Horticultural Society (RHS) subsequently published two 'Horticulture Matters' reports[11,12] further emphasising the impact of a lack of relevant training. Two thirds of the employers who responded to the RHS survey indicated that career entrants were inadequately prepared for work.

Within the Plant Science community, represented by the UK Plant Sciences Federation (now, the Plant Science Group of the Royal Society of Biology), similar concerns were more explicitly stated. 'Employers and educators should provide more and better-targeted apprenticeships, employee training, industrial studentships, degree content, further education and postgraduate courses. Training should be a core requisite of the Centres for Agricultural Innovation created through the UK Strategy for Agricultural Technologies. Education and training opportunities must be directed to fill skills gaps in plant taxonomy and identification, crop science, horticultural science, plant pathology, field studies and plant physiology (authors emphasis)'.[13] The 'Growing the Future' report[14] from the same organisation some years later highlighted plant health and biosecurity as areas of particular need.

The Ornamental Horticulture Group Roundtable (a sector-led group formed with support from Department of Environment Food and Rural Affairs [DEFRA]) commissioned two reports towards the end of the same decade. One focused on the economic impact of ornamental horticulture and landscaping in the United Kingdom,[15] the other focused on the skills shortages and gaps within the ornamental horticulture industry workforce.[16] Biosecurity knowledge was deemed to be one of the more significant areas of skills gap for managers, directors and senior officials. Furthermore, when employers were surveyed for their perceptions of which job roles would benefit from the holder having a degree qualification, the role of soil scientist had the highest importance of all (at 70%).

A subsequent survey commissioned by the Agriculture and Horticulture Development Board (AHDB) focusing on the Edible Horticulture Sector[17] found that 'A small but notable proportion of qualitative responses argue that the level of skills, especially of new workers joining the sector, is deteriorating year on year'.

The problem continues – an independently conceived UK Plant Science Research Strategy published in January 2021[18] states that 'there is a lack of strategic oversight to ensure that training opportunities align with predicted future need for skills'. Despite outlining an educational shortage in plant science (i.e., at undergraduate degree level), the same report indicates a relatively healthy plant science research base at some UK universities. 'Plant science research is currently represented in 48 UK universities, with ~50% having sufficient staff to teach a broad range of plant sciences at undergraduate level. Very few research active universities offer vocation targeted courses such as agriculture, plant breeding and forestry'.[18]

These conflicting observations would suggest that the research interests of academics may not be reflected in the modules and degree courses offered by UK Higher Education Institutions (HEIs). Additionally, it is worth noting that although 48 UK universities may have strong plant science research, approximately 145 UK universities teach biological sciences (UCAS searches 2021, 2022) of which plant science should be a core component.

More recently the importance of plants to UK health and the economy has been recognised through both the National Food Strategy[19,20] and the Biosecurity Strategy policy paper.[21] The National Food Strategy and proposed plan[19,20] takes an holistic view on climate change, environment, food production, processing and health. To meet the goals of this plan, it is going to require a skilled and plant aware workforce. In particular, appropriately trained and skilled scientists will be needed to undertake the research required to support increased fruit and vegetable production and the move to alternative protein sources. Whilst the Biosecurity Strategy[21] has a strong focus on the importance of education, there is no mention of improving the

content of undergraduate degree courses with regard to biosecurity issues, rather focusing on pre-university (both GCSE and A Level) and masters level education as well as offering summer internships and projects through the Plant Health Undergraduate Scheme.

The economic importance of plants, botany and horticulture to the United Kingdom cannot be understated. In 2022, home production of fruit, vegetables and ornamentals was estimated to be worth £4.3 billion to the UK economy.[22] The National Plant Biosecurity Strategy policy paper published in 2023[21] cited the annual value of plants at £15.7 billion.

Despite the economic importance and the past decade of reports highlighting the need for plant education, there has been little detailed work looking at what is being taught at degree level in the United Kingdom, although a recent viewpoint publication offers up some analysis of biology courses run at Russell Group Universities.[23] To address this lack of knowledge, here we investigate the curricula of the full range of relevant UK HE undergraduate courses to determine the breadth of plant-related teaching and how they are responding to the skills shortages highlighted above. We sought to consider the issue holistically and cut across the traditional boundaries of plant science, horticulture and botany to include in our study all courses that should be expected to teach a significant proportion of plant-related material. We present a systematic analysis of what is being delivered on degree programmes that specifically 'self-identify' as providing education about plants. To our knowledge, this is the first time such a detailed analysis of curricula across the breadth of educational settings has been undertaken. Our findings are discussed in relation to the skills shortages and training necessities we have summarised above.

METHODS

Identification of plant 'self-identifying' courses

The Universities and Colleges Admissions Service (UCAS) is the clearing house of all advertised UK HE programmes. Three initial searches were performed on the UCAS website in May 2020 using the keywords 'botany', 'horticulture' and 'plants' as individual search terms to look for undergraduate courses.

The search term 'botany' provided a list of 37 undergraduate courses offered by 13 institutions, 'horticulture' resulted in a list of 145 courses offered by 37 institutions, and 'plants' gave a list of 115 courses offered by 40 institutions. However, we found some overlap in course listing for the search terms used therefore, the search results were combined and duplicates removed. On inspection of the de-duplicated combined list, it was clear that there were a number of courses identified that were not relevant to our investigation and these were also removed from the list. Examples of such course titles included: animal science, bioveterinary science, canine studies, construction technology, economics and finance, equine studies, geography and sports science.

With this dataset in hand, additional searches were conducted using the keywords 'crop' and 'food'. The 'crop' keyword search identified 51 courses from 14 institutions of which 25 were not already on the combined list. These were added into the total dataset. The search term 'food' did not provide any relevant courses in addition to those already on our list. A full list of courses included and excluded (and the rationale behind the exclusion) can be found in Data S1 (courses).

Data collection

For each course identified in our searches, publicly available data from university websites was gathered about all modules offered, whether optional or compulsory. The content of each module, as described on university websites, was then examined to determine whether a specific topic was present or absent. The list of topics against which to score was created using an iterative process, initially scoring a random sub-set of modules. Two rounds of scoring and discussion led us to developing a finalised list of 63 topics. These covered both plant-related and non-plant-related topics, and included those areas of skills shortages identified in many of the reports discussed in the introduction. The full list of topics is available in Data S2 (topics scored).

The level of agreement between scorers assessing the presence or absence of topics from module descriptions was assessed by getting three different scorers to each score a test-set of courses. We used a Fleiss's Kappa analysis[24] computed using the irr R package[25] to quantify the level of consistency between scorers as $\kappa = 0.71$. This was deemed to be good, but also highlighted that there were occasionally significant differences. Therefore, a final protocol was developed in which each module was scored independently by two individuals, and where discrepancies occurred, a third, independent scoring was undertaken. All modules were then scored using this double scoring method.

When data collection was embarked upon, it was found that some institutions no longer offered all the courses listed. Furthermore, some institutions did not provide sufficient information about module detail on publicly accessible websites (such as potential students would have access to), to enable completion of full module scoring. Ultimately the final scoring was conducted on 3165 modules, across 127 undergraduate courses at 32 institutions. The fully scored dataset is provided in Data S3 (Scored dataset).

Data analysis

All data analysis, summaries and visualisation were carried out in R[26] using the packages tidyr, dplyr, ggplot2, gridExtra, cowplot and viridis.

To generate a summary of the number of modules, courses and institutions teaching each topic, the dataset was first filtered to contain only those where topics were scored as present, data was grouped by topic, and distinct entries counted for module, course and institution.

As the dataset was large and complex, courses were grouped into 6 categories: 'Plant Science', 'Horticulture', 'Agriculture', 'General Biology', 'Ecology/Conservation' and 'Other Specialism' to aid the

visualisation of results. These groupings were based on the degree titles. Details of which specific courses were grouped into which categories is provided in Data S4 (Course Groupings).

To determine the proportion of modules on each course that deliver content on plant topics, all 63 topics were categorised into broad groupings of 'Plants' (33 topics), 'Non-plants' (21 topics) and 'Other' (9 topics), a grouping of dissertation and skill-based modules (Data S5 [Criteria groupings]). The dataset was filtered to contain only those entries where the broad category grouping 'Plants' was present. Data were grouped by course, and distinct entries counted across module. This provided a count of the number of modules containing some content about plants for each course, which was divided by the total number of modules for that course. Dissertation modules posed a dilemma, as they are not content modules in the way that most modules being scored were. In order to ensure that this was not skewing the results, the analysis was repeated with modules that were scored as dissertation modules removed. The analysis presented here is with dissertation modules removed.

Within a university course a single module might teach one topic or many topics. To understand whether modules deliver content solely on plant topics, or on many topics, we looked at the uniqueness of plant teaching content within a module. The dataset was filtered to remove modules that were dissertation modules. Topics that were classified as 'Other' (skills modules not content delivery modules) were also removed from this analysis, so that this analysis is only scoring modules containing topics of 'Plant' or 'Non-plant'. Skills modules were identified as modules teaching a skill such as statistics or experimental design, rather than a 'Plant' or 'Non-plant' subject. For each course the following statistics were produced: the total number of modules, the number of modules teaching uniquely plant content (modules where only 'Plant' topics were present), the number of modules teaching mixed content (modules where both 'Plant' and 'Non-plant' were present) and the number of modules teaching uniquely non-plant content (modules where only 'Non-plant' topics were present). Modules where only 'Other' topics were present were removed completely from the analysis.

To understand in more detail how the teaching of particular topics was distributed between different course types, the following measures were calculated: the number of times a topic was present for each course type, the total number of times a topic was present, the number of times a topic was present in each course type divided by the total number of times a topic was present across all courses. These data were used to generate a heatmap of both the proportion of present scores distributed amongst topics and course types, as well as the absolute number of present scores distributed amongst topic and course types.

Terminology

We use the following terminology to describe our results:

Institution□an organisation delivering teaching; Course□a programme of study; Module□a component of a programme of study; Topic (subject topic)□actual subject material, a list is provided in Data S2. Modules vary in credits, a standard BSc (Hons) requires a total of 360 credits to be obtained (120 credits a year for 3 years).

Topic Areas are subgroupings of the total 63 topics and include: Plant Topics (33 specific topics of only plant subject matter), Dissertation modules, Skills Topics (not subject specific matter but focussing on skill development).

RESULTS

From the interrogation of publicly available information, we identified 127 courses offered by 32 institutions that self-identified as containing plant-specific content. Scoring against our 63 topics (Data S2) produced 199,395 data points of which 10,175 were positive scores for a topic. There was wide variation in the number of modules, courses and institutions teaching the different plant topics and a full summary of the number of modules, courses and institutions teaching each topic can be found in Data S6 (Criteria summary).

Plant teaching at institutional level

To obtain an impression of the spread of topic areas taught across institutions, an initial analysis was performed (Figure 1) in which the number of institutions having at least one positive score for a plant-specific topic area occurring on at least one module on at least one course was plotted against the 33 plant-specific topic areas.

It is interesting to note that not a single one of the plant-specific topic areas is offered/taught by all institutions. Taxonomy is offered by the largest number of institutions (27 out of 32) whilst practical horticulture, and related 'horticulture' topics, are offered by 7 or fewer institutions. Only 13 (out of 33) plant-specific topics are taught/offered by more than half the institutions (16+).

Plant teaching at course level

We next expanded our analysis to obtain an impression of the spread of topic areas taught across courses (Figure 2), in which the number of courses having at least one positive score for a plant-specific topic area occurring on at least one module was plotted against the 33 plant-specific topic areas.

This analysis revealed that again not a single plant-specific topic is offered/taught on all courses, and that only 4 plant topic areas are taught on half the courses (64+ out of 127). These 4 topic areas are: taxonomy, plant ecology, plant pests and disease, and landscape management. Practical horticulture, and related 'horticulture' topics, are offered/taught on 15 or fewer courses out of 127.

These initial analyses revealed that there is wide variation between institutions as to which topics are taught on courses, and that there is no basic (minimum) or consensus plant curriculum.

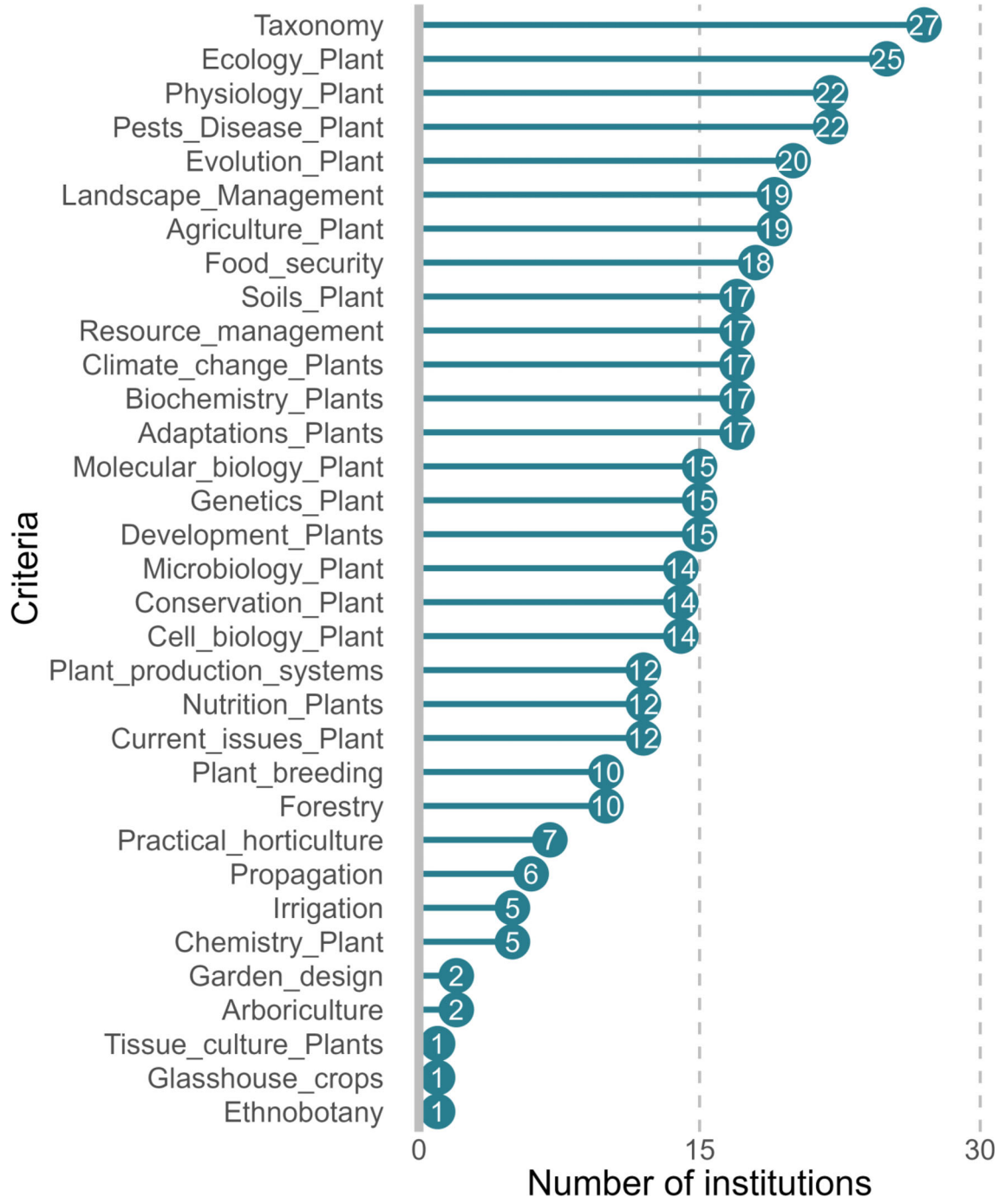

FIGURE 1 Number of institutions running courses that contain at least one module with some teaching on the specified plant-related topic. Number shown in circle is the total number of institutions.

Plant teaching at module level

We next sought to understand the proportion of modules containing plant teaching within the courses identified. Courses were grouped into 6 categories according to degree title to aid in data visualisation. The data are complex with different institutions offering courses of differing length and containing modules of differing credit weighting. Courses ranged from a 1-year degree 'top up', a 2-year foundation (FdSc), or a 3- or 4-year degree; whilst modules could be 10 credit, 15 credit, 20 credit, 30 credit and 40 credit. The proportion of modules for each course that scored positive for at least one plant specific topic is summarised in Figure 3.

Figure 3 illustrates clearly the diversity in course length offered and consequently the different module number used in the analysis.

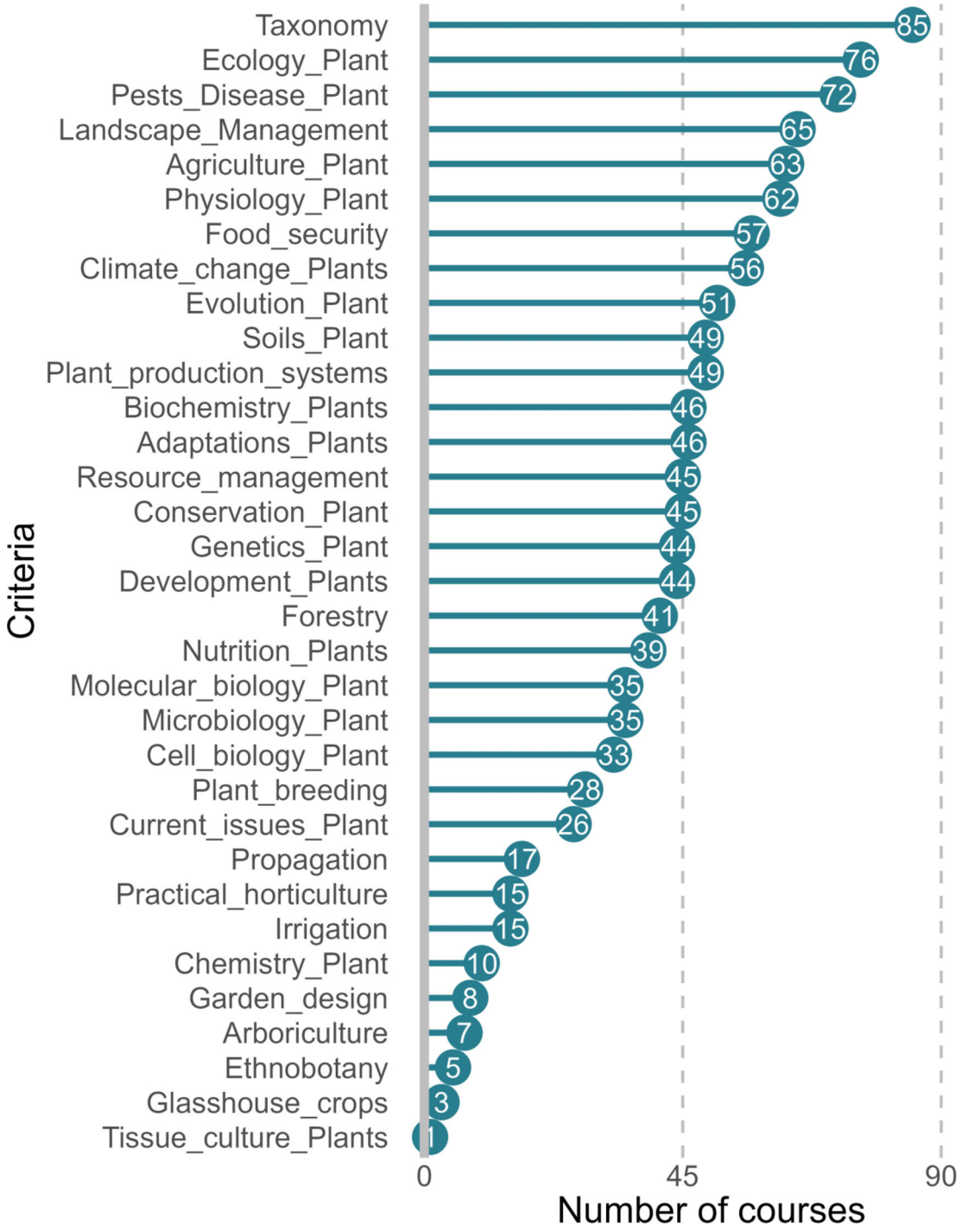

FIGURE 2 Number of courses containing at least one module with some teaching on the specified plant-related topic. Number shown in circle is the total number of courses.

For example, courses grouped under 'horticulture' contain the highest proportion of non-standard length courses (8 out of 12) and consequently fewer modules in this analysis.

The 127 courses identified span a whole range of plant content teaching (topics), ranging from no plant content (0) to every module containing plant content (1). Three courses had all modules scored as containing some plant teaching content, of which two were grouped with the 'Agriculture' courses and one grouped with the 'Horticulture' courses. These courses contained relatively few modules and were not of the standard 3–4-year degree length. Ninety-three courses had less than a half of their modules containing plant teaching content (topics), with the majority of these courses being categorised under 'General Biology'. Teaching content (topics) within a module varies greatly depending on the type of module and the degree course structure. Our initial analysis derived 10,175 scores against our 63 topic areas from scoring 3165 modules comprising the 127 courses. This suggests that on average, any given module may be expected to deliver content from at least 3 topic areas.

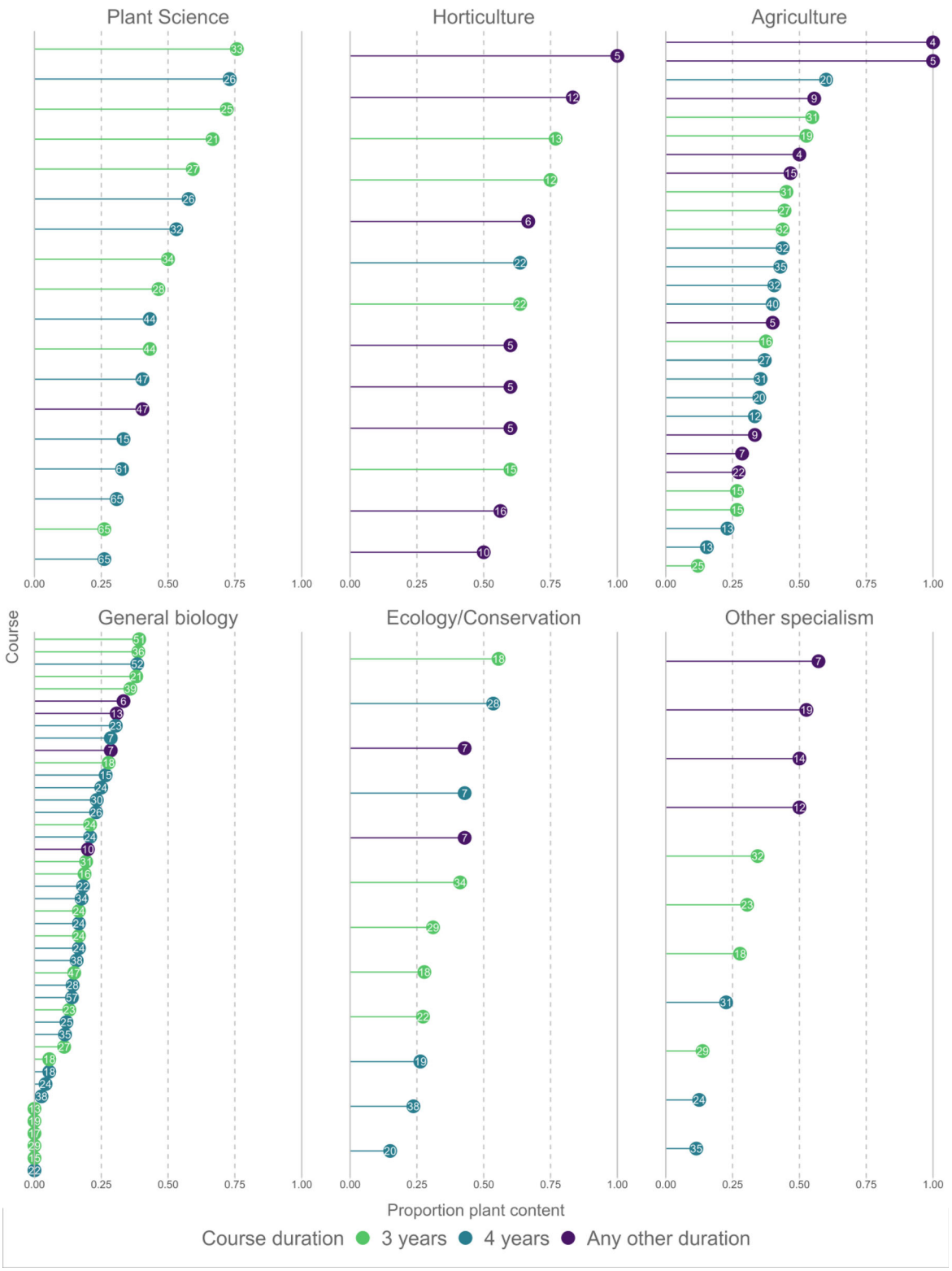

FIGURE 3 The proportion of modules teaching plant content in each course. The proportion is based on the number of modules that score against at least one plant topic out of the overall number of modules. Each line on the charts represents a single course. The number in the circle is the total number of modules included in the analysis for that course. Point colours represent the course duration. For courses listed as 'any other duration', the course could be 1, 2 years, or five or more years. These courses include foundation courses, Higher National Certificates and Higher National Diplomas as well as extended undergraduate masters degrees.

Plant teaching in focus

To gain an understanding of whether plant topics were primarily taught in modules on their own, or mixed with other areas of teaching, we looked at whether teaching content in a module is exclusively on plant-related topics, exclusively non-plant-related topics, or a mixture of plant and non-plant topics across each course. The results are summarised in Figure 4.

Interpretation of the proportion of plant content outlined in Figure 4 should be undertaken with reference to the total number of content delivery modules included in the analysis. Figure 3 displays the variety of course length, and this variety is represented in the number of modules offered. For example, a standard 3-year degree of 360 credits could contain a 40 credit dissertation module and at least one 20 credit skills module (statistics) so would consist of fifteen 20 credit content modules. The variation in module number for courses used in the analysis shown in Figure 4 reflects these differences in course length, as well as differences in options offered on courses and differences in module length (credits).

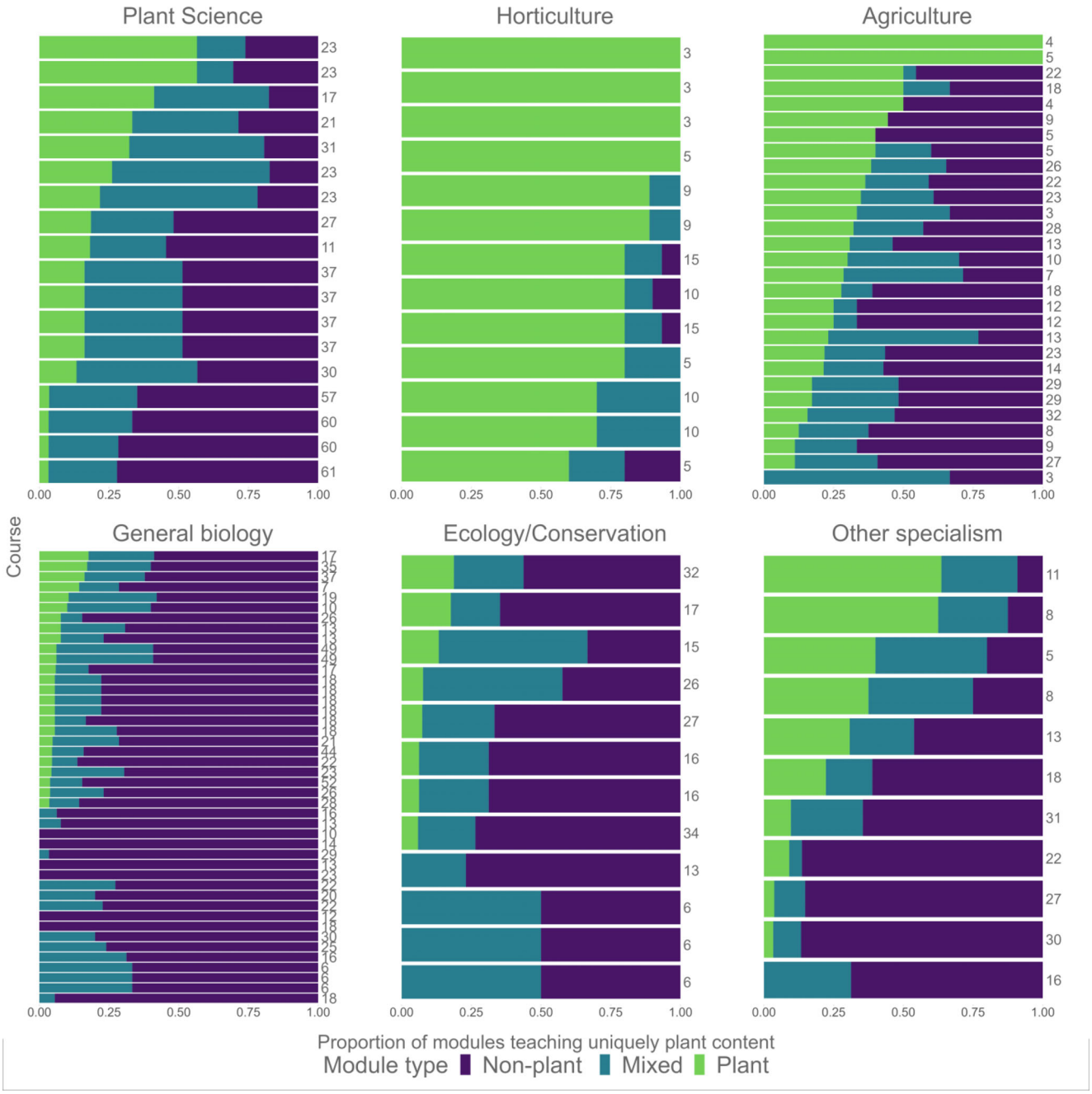

FIGURE 4 The proportion of modules in a course teaching uniquely plant content, mixed content or uniquely non-plant content, ranked by the proportion of uniquely plant content. Each bar represents a single course. The number to the right of the bar is the number of modules that are included in the analysis for that course.

Across all courses, the majority of teaching is delivered in non-plant content modules, and where plant content is delivered, this is split between mixed modules and plant-specific modules. The majority of plant teaching is delivered in the mixed modules, with the plant-specific modules being the least frequent across the sector. What can be seen clearly in Figure 4 is that Horticulture courses as a whole teach a significant amount of directly plant-relevant content, though many courses consist of few modules, representative of 'top up' or foundation (FdSc) courses. By contrast, the situation for Plant Science courses (module number suggests these are full degree courses) is mixed, with some courses that teach only a very small amount of directly plant-related content. The proportion of plant science-specific teaching is particularly low for courses categorised as General Biology, even though these courses self-identify as containing plant content.

Plant teaching variation with course type

Finally, we sought to understand the distribution of plant content teaching between different types of courses. For each plant content topic, the number of scores was counted for each module and collated against each course and grouped by the 6 generalised subject types for courses. Additionally, for each plant content topic, the number of scores for each course type was divided by the total number of scores obtained for that topic to give a proportion. These data are summarised in Figure 5.

The teaching of different topics is not distributed evenly between different course types, with some topics only taught on particular courses. For example, garden design is only taught in Horticulture course types whilst practical horticulture is primarily taught in Horticulture course types, and there are no General Biology courses which

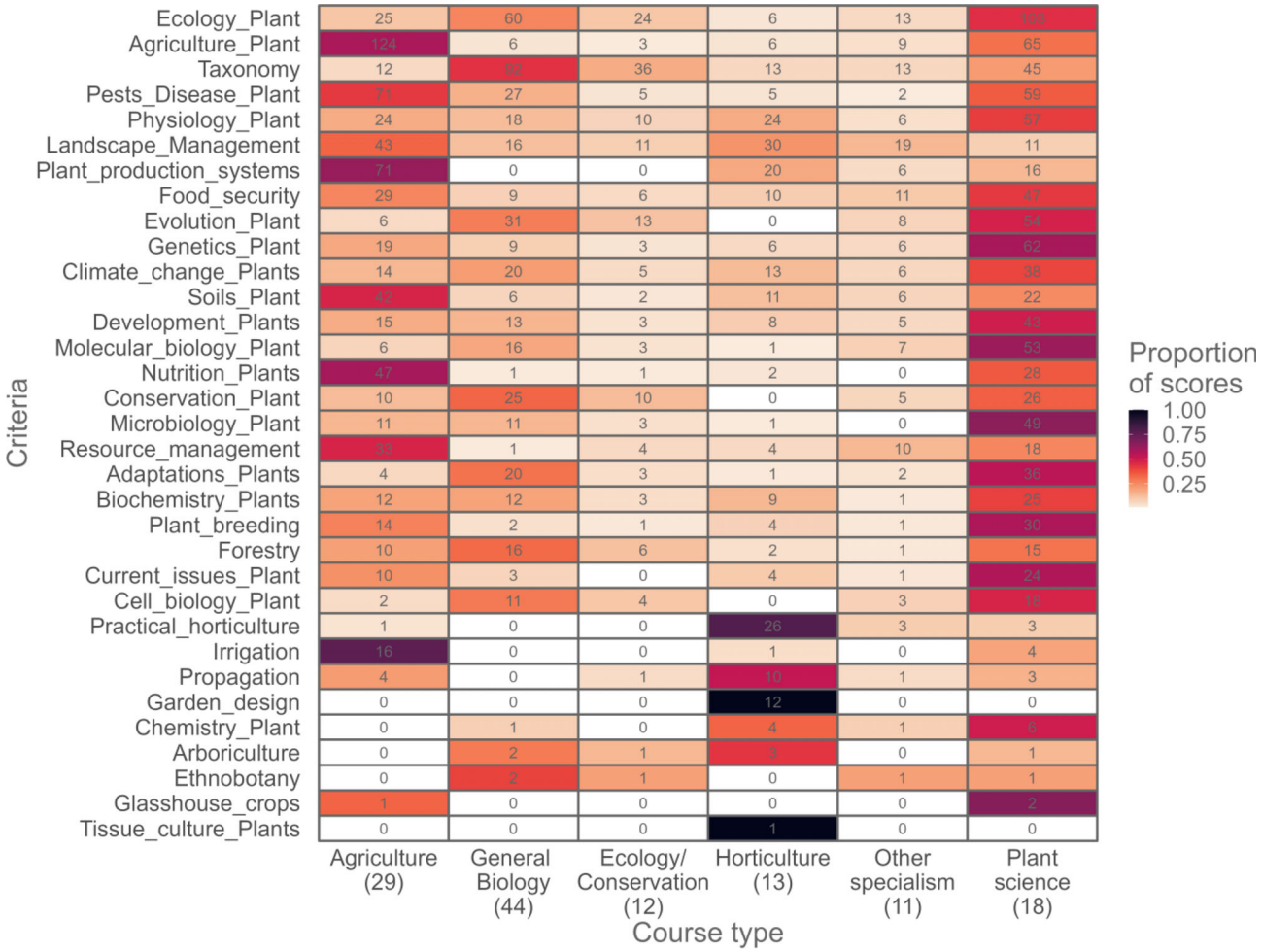

FIGURE 5 Heatmap showing the distribution of teaching of topics between the different course types. The number in the box is the absolute number of times the topic was found to be present in those course types in the dataset. The colour of the box represents the proportion of present 'scores'" out of the total number of 'scores' for that particular topic. Topics are sorted descending by total number of present scores. The number in brackets underneath the course type is the number of courses grouped within that category. Institutions offer multiple courses and courses in multiple categories. The number of institutions delivering courses in each category is as follows: Agriculture 8, General Biology 15, Ecology/Conservation 8, Horticulture 4, Other Specialism 7, and Plant Science 9.

teach anything about plant production systems. Practical horticulture is rarely taught in Plant Science-specific degree courses. This highlights the valuable information contained within the full dataset, which is not seen in the higher-level summaries.

Overall, the heat map reveals that the most substantial plant teaching occurs on courses in the Plant Science course types, with Agriculture and Horticulture course types offering a high proportion of certain plant-specific topics.

Further analysis of plant science courses

As most plant science topics are delivered by courses within the plant science course grouping, further analysis was undertaken to see if in this group a minimum curriculum could be identified. The number of courses with some teaching of one of the plant-specific topics was plotted against each topic. This analysis revealed that all 18 courses in the grouping delivered teaching on: plant physiology; plant evolution, adaptations, and ecology; food security and agriculture.

DISCUSSION

This work presents a systematic assessment of plant teaching content in the UK HE system on courses that are expected to have a significant proportion of plant teaching (courses that have 'self-identified' as delivering plant content). Our analysis has highlighted wide variation in the number of courses and institutions teaching particular plant-related topics. We have also identified substantial differences in the proportion of plant content within specific degree courses, and the distribution of topics between different course types.

Are the curricula serving national priorities?

At the outset we asked the question 'is plant science policy reflected in higher education curricula?' The short answer to this question is undoubtedly no! Our analysis reveals a complex situation and the absence of any plant science curriculum common to institutions or courses.

A longer answer to the question is not really, but there are pockets of plant content delivery of strategic importance. However, these pockets occur across a variety of courses of varied length and type offered by a range of institutions and are consequently difficult for any prospective student (or employer) to identify. The only common curricula we identified was limited to the 18 courses we grouped as Plant Science, which are delivered by just 9 institutions.

This complexity and lack of consensus between institutions as to what constitutes a plant curriculum can be illustrated by looking at the topic area of plant physiology. Plant physiology is taught on 62 (out of 127) of the courses (Figure 2) offered across 22 (out of 32) institutions (Figure 1). Plant physiology might be expected to be so fundamental to the understanding of plants as to be a requisite of all courses identified in this study, not just core on the 18 plant science-specific courses.

Not only is there no consensus curriculum, our analysis shows that plant content teaching constitutes less than half of the teaching across the courses (Figure 4), and where plant teaching occurs it is on modules of mixed content (Figure 4). These mixed content modules commonly contain plant and non-plant subject topics and so the actual amount of plant subject-specific teaching is probably low (less than half the module content) as on average every module we scored covers just over three subject topic areas.

If a course is titled 'Plant Biology' or 'Plant Science', we believe it is reasonable to expect that a majority of modules would indeed have a plant focus. Similarly, if a course 'self identifies' as teaching plant content, we consider it reasonable to expect a substantial (if not majority) proportion of the subject-specific delivery to cover plant topics. It is also reasonable to expect all such courses to have a basic, or minimum, curriculum consisting of 3–4 plant-specific modules covering aspects of basic plant biology.

From the initiation of this project, we sought to understand the detail about the plant-related topics being taught at HE level in the United Kingdom. Specifically, we wanted to look at the areas highlighted as suffering from skills shortages or of particular importance from a national strategic perspective.

Soil science was identified as an area of skill shortage by both the Foresight report[10] and by the Ornamental Horticulture Round Table report.[16] The job role of soil scientist was also identified as that which would benefit the most from the holder having a degree qualification. Our data show that the topic of soil science (in the context of plants) is offered on 49 courses (Figure 2) across 17 institutions (Figure 1) and features predominantly within modules of specialist degree courses: with most occurrences being on Agriculture courses (42 occurrences within the dataset of 29 courses; Figure 5), with Plant Science courses having the second highest number of occurrences (22 across 18 courses; Figure 5) and Horticulture the third highest (11 across 13 courses; Figure 5). What we cannot interpret from our dataset, as presented, is whether these occurrences are evenly distributed across the courses or feature strongly in just a small number of them. It is interesting, however, to note that there are just 6 instances of soil science (in the context of plants) being taught across the 44 General Biology courses in our dataset (Figure 5).

The UK Plant Science Federation report in 2014[13] stated that the skills gap in plant pathology (amongst other areas) needed to be addressed. The national Biosecurity Strategy report[21] emphasises the need for qualified personnel to work in this area. Our data reveal that the topic of plant pest and disease is offered on 72 courses (Figure 2) across 22 institutions (Figure 1) with the highest proportion of teaching occurring on Plant Science courses (59 instances across 18 courses; Figure 5), with Agriculture courses coming a close second (71 instances across 29 courses; Figure 5). Perhaps surprisingly, there are only 5 recorded instances of this topic being taught across the 13 Horticulture courses in our dataset. The 44 General Biology courses are recorded as having 27 instances of the teaching of the topic of plant pests and diseases (Figure 5).

That one of the UN's 17 SDGs is 'Zero Hunger' shows how important awareness of food security and work towards achieving it is today. From our data we can see that food security as a topic is offered on 57 courses (Figure 2) across 18 institutions (Figure 1). There are 29 instances where this topic is taught across the 29 Agriculture courses (Figure 5) and 47 instances across the 18 Plant Science courses (Figure 5), but worryingly this topic, of immense global importance, only features in 9 of the 44 General Biology courses within our dataset (Figure 5), meaning the majority of General Biology courses have no described teaching on food security within their module specifications.

A second SDG of 'Climate Action' is no less important. However, there were fewer occurrences of the teaching of this topic being taught in relation to plants across all courses within our dataset than for food security (a total of 96 compared to 112). Climate change in relation to plants is taught as a topic on 57 courses (Figure 2) across 17 institutions (Figure 1) with this topic featuring most within the Plant Science courses (38 instances across 18 courses; Figure 5) followed by General Biology (20 instances across 44 courses; Figure 5). It is concerning that there are only 14 instances of this topic being taught across the 29 Agriculture courses (Figure 5)□an area of industry that needs to reduce its climate impact significantly.[27] However, the plant-related topic taught most frequently (from within our dataset) is plant ecology. Plant ecology is taught on 76 courses (Figure 2) spread across 25 institutions (Figure 1). This is an important topic with relevance to that of climate action, and aspects of climate change may well be covered within these modules.

A comparison of the numbers of courses and institutions teaching a particular topic reveals that largely, each topic when taught is delivered on multiple courses within that institution. For instance, the widely taught topics of ecology and plant health are taught on 76 and 72 courses (Figure 2), but at only 25 and 22 institutions, respectively (Figure 1). The far less widely taught topics of ethnobotany and arboriculture are taught on 5 and 7 courses (Figure 2), but only 1 and 2 institutions, respectively (Figure 1). This could be because multiple modules covering the topic are taught on multiple courses within any institution, or it could be due to the same module being taught on multiple courses or for both reasons. For example, at just one particular institution, the topic of ecology was taught on 24 different courses, with this equating to just 11 unique modules. Arboriculture, taught on 7 different courses across 2 institutions, was found to be in just two different modules (1 at each institution). The 5 different courses at a single institution that were found to teach ethnobotany all used the same module.

Higher educational institutions (HEIs) and plant awareness disparity (PAD)

It became clear to us during the gathering of our base set of courses, that the majority of General Biology (or biological sciences) courses had not been identified from our initial searches. Separately, we identified a total of 182 biology courses from across 79 institutions, only 26 of which were on our final list of courses scored (with 6 of these being on our list of courses we wanted to score but could not) (Data S1). That the vast majority of courses that can be found on the UCAS website via a search for General Biology courses are not found when using a plant-related search term, is concerning. This, together with the data we gathered showing the low frequency of plant-related topics within the General Biology courses that did make it into our dataset, builds a picture of biology teaching at HEIs in the United Kingdom showing a concerning level of PAD. It is possible that these courses may have some plant-related content but just do not identify this on UCAS.

HEIs and information for prospective students

When embarking on the scoring phase of our project, we found that there was a wide diversity in the amount of information made available by university websites about their course structures and module content. Some courses, that through prior knowledge of the system, we 'know' to feature plant content are not part of our dataset because the information was not accessible from public websites. How the course and module descriptions were written also impacted on whether we were able to score for the presence or absence of particular topics. Some descriptions were extensive with sufficient detail, others brief and at a much higher, more general level.

We suggest it is a necessity for HEIs to provide sufficiently detailed, accurate descriptions of their courses and the modules contained within them. We encourage those writing these descriptions to state what kinds of organisms are being used as illustrative examples within topics (animal, fungi, microbe, plant, etc.) and to use examples from across the natural world where possible, rather than focusing on animal examples.

The HEI marketplace is competitive and complex. Institutions compete for students and are driven by economic concerns about student numbers. Anything that might 'put a student off' from applying to a course is avoided and unpopular modules and courses are terminated. The anecdotal evidence we have heard about plants not being an interesting topic of study is in direct opposition to the need for a future plant-aware and educated workforce that will ensure food security, biodiversity conservation, enable a positive response to climate change and more.

Indeed, since undertaking this systematic review of plant-related HE courses, the Horticultural Sector Committee of the House of Lords has published a report 'Sowing the seeds: A blooming English horticultural sector'[28] in which they state: 'A chronic shortage of workers at all skills levels' including a section on HE. It identifies that HE courses are not serving the skills requirements of the horticulture sector. Specifically, it encourages 'universities offering courses in Plant Science, Horticulture or Botany to revise their module list considering the skills needed in the sector, to ensure that their graduates are trained to meet the challenges of the industry'. What remains unknowable is what quantity of courses teaching specific plant-based topics is required to meet the skills knowledge requirements identified by the many reports outlined above.

CONCLUSIONS AND FUTURE WORK

From the beginning we sought to undertake a systematic analysis of all UK HEI courses that self-identified as teaching topics within the boundaries of plant science, horticulture and botany. Identifying that many General Biology programmes were not included in the study presented here leads to the next logical piece of work to systematically evaluate the publicly available information on the curricula of those courses, looking in particular at the content teaching about plant topics.

The project to date has been based on the publicly accessible data which provides information on quantity, but not quality of teaching. A future analysis should include making more detailed assessments of particular courses of interest to understand what facilities are available for the teaching and how the plant content that is delivered is supported by these. Finally, it would be instructive to repeat this exercise in 5 years' time once the curriculum reviews that we know to be taking place have been implemented.

ACKNOWLEDGEMENTS

Funding for the work of Adam Scanlon was provided by the Society of Chemical Industry. Sophie Read, Matteo Luberti and Thomas Haven were funded through a CTP as part of their doctoral studies. We thank members of the SCI horticulture committee for support and helpful discussions, with particular thanks to David Atkinson as Chair whilst the majority of this work was undertaken, and for specific feedback on a final draft of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors Alec Forsyth, Alison C. Foster and Sarah Trinder are all employed in the higher education sector. Alec Forsyth teaches on courses that were studied as part of this work.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the Supplementary Material of this article.

ORCID

Sarah Trinder https://orcid.org/0000-0002-0767-9912
Thomas Heaven https://orcid.org/0000-0003-3193-4896
Matteo Luberti https://orcid.org/0000-0002-3667-2920
Sophie Read https://orcid.org/0000-0003-2067-4793
Alec Forsyth https://orcid.org/0000-0002-4283-3583
Alison C. Foster https://orcid.org/0000-0003-3634-5150

REFERENCES

1. Wandersee JH, Schussler EE. Preventing plant blindness. USA: University of California Press; 1999.
2. Wandersee J, Schussler E. Towards a theory of plant blindness. Plant Sci Bull. 2001;47(1):2.
3. Parsley KM. Plant awareness disparity: a case for renaming plant blindness. Plants People Planet. 2020;2(6):598–601. https://doi.org/10.1002/ppp3.10153
4. Jose SB, Wu CH, Kamoun S. Overcoming plant blindness in science, education, and society. Plants People Planet. 2019;1(3):169–72. https://doi.org/10.1002/ppp3.51
5. Parsley KM, Daigle BJ, Sabel JL. Initial development and validation of the plant awareness disparity index. CBE Life Sci Educ. 2022;21(4):ar64. https://doi.org/10.1187/cbe.20-12-0275
6. Ahi B, Atasoy V, Balci S. An analysis of plant blindness in Turkish textbooks used at the basic education level. J Balt Sci Educ. 2018;17(2):277–87.
7. Brownlee K, Parsley KM, Sabel JL. An analysis of plant awareness disparity within introductory biology textbook images. J Biol Educ. 2021;57(2):422–31. https://doi.org/10.1080/00219266.2021.1920301
8. United Nations. Transforming Our World: The 2030 Agenda For Sustainable Development. 2015 Available from: https://sdgs.un.org/2030agenda
9. Amprazis A, Papadopoulou P. Plant blindness: a faddish research interest or a substantive impediment to achieve sustainable development goals? Environ Educ Res. 2020;26(8):1065–87. https://doi.org/10.1080/13504622.2020.1768225
10. The Government Office for Science. Foresight. The Future of Food and Farming. 2011 Available from: https://assets.publishing.service.gov.uk/media/5a7bf9f840f0b645ba3c5efe/11-546-future-of-food-and-farming-report.pdf
11. Royal Horticultural Society. Horticulture Matters 2013. 2013 Available from: https://www.rhs.org.uk
12. Royal Horticultural Society. Horticulture Matters 2014. 2014 Available from: https://www.rhs.org.uk/education-learning/pdf/training/1016-rhs-hort-careers-brochure-v8.pdf
13. UK Plant Sciences Federation. UK Plant Science: Current status & future challenges. 2014 Available from: https://www.rsb.org.uk/images/pdf/UK_Plant_Science-Current_status_and_future_challenges.pdf
14. UK Plant Sciences Federation. Growing the future. 2019 Available from: https://www.rsb.org.uk/images/UKPSF_Growing_the_future.pdf
15. Oxford Economics. The Economic Impact of Ornamental Horticulture and Landscaping in the UK a Report for the Ornamental Horticulture Round Table Group. 2018 Available from: https://www.rhs.org.uk/science/pdf/the-economic-impact-of-ornamental-horticulture-and.pdf
16. Pye Tait Consulting. 2019 Horticulture Sector Skills Survey A report for the Ornamental Horticulture Roundtable Group. 2019 Available from: www.pyetait.com
17. Pye Tait Consulting. Edible Horticulture Skills 2020 Sector Report. 2020 Available from: www.pyetait.com
18. Langdale J. UK Plant science research strategy. A Green Roadmap for the Next Ten Years. 2021 Available from: https://www.ukri.org/news/ten-year-roadmap-to-guide-uk-plant-science/
19. Dimbleby H. The National Food Strategy. Part One. 2020 Available from: https://www.nationalfoodstrategy.org/part-one/
20. Dimbleby H. The National Food Strategy. Part Two. 2021 Available from: https://assets.publishing.service.gov.uk/media/61684fe3e90e071979dfec4a/national-food-strategy-the-plan.pdf
21. Plant biosecurity strategy for Great Britain (2023 to 2028). 2023 Available from: https://www.gov.uk/government/publications/plant-biosecurity-strategy-for-great-britain-2023-to-2028/plant-biosecurity-strategy-for-great-britain-2023-to-2028
22. Horticulture Statistics 2022. National Statistics. 2023 Available from: https://www.gov.uk/government/statistics/historical-national-statistics-on-horticulture/horticulture-statistics-2022-published-on-8-june-2023
23. Stroud S, Fennell M, Mitchley J, Lydon S, Peacock J, Bacon KL. The botanical education extinction and the fall of plant awareness. Ecol Evol. 2022;12(7):e9019. https://doi.org/10.1002/ece3.9019
24. Fleiss JL. Measuring nominal scale agreement among many raters. Psychol Bull. 1971;76(5):378–82. https://doi.org/10.1037/h0031619

25. Gamer M, editor. Irr: various coefficients of interrater reliability and agreement. R package version 0.84.1. 2019 Available form: https://www.rdocumentation.org/packages/irr/versions/0.84.1
26. R Core Team. A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2008.
27. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, et al. Food in the Anthropocene: the lancet commission on healthy diets from sustainable food systems. Lancet. 2019;393(10170):447–92. https://doi.org/10.1016/S0140-6736(18)31788-4
28. Sector Committee, H. House of Lords Horticultural Sector Committee Report of Session 2022–23 Sowing the seeds: A blooming English horticultural sector. 2023 Available from: https://www.parliament.uk/mps-lords-and-offices/standards-and-interests/register-of-lords

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Trinder S, Heaven T, Luberti M, Read S, Scanlon A, Gauntner C, et al. Analysis of plant science higher education reveals mixed provision which falls short of delivering national priorities. JSFA Reports. 2025. https://doi.org/10.1002/jsf2.70001