

“THREE INTEGRATIONS AND THREE DRIVES”: CONSTRUCTING AND PRACTICING AN INNOVATIVE TALENT CULTIVATION SYSTEM FOR TROPICAL CROP PRODUCTION MAJORS

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Abstract: Amid the dual context of building an agricultural powerhouse and advancing novel productive forces, the tropical crop industry is accelerating its transition towards intelligence, sustainability, and internationalization, thereby imposing heightened demands on the interdisciplinary aptitude and practical capabilities of innovative talents. Addressing prevailing challenges such as pronounced disciplinary barriers, superficial industry-education integration, and insufficient international adaptability in the training of tropical crop production professionals, this study proposes a “Three Integrations and Three Drives” talent cultivation system. This framework centers on the core pathways of interdisciplinary integration, profound industry-education integration, and synergistic scientific-educational collaboration, propelled by the engines of industry demand, cutting-edge technology, and international cooperation. Through curriculum restructuring, pedagogical innovation, enhancement of practical platforms, and reform of assessment mechanisms, this approach achieves synchronous resonance among talent development, industrial progress, technological advancement, and global needs. The proposed system offers a replicable and scalable model for talent training in tropical crop majors under the new agricultural science paradigm.

Keywords: Tropical crops; Talent cultivation; Three integrations and three drives; New agricultural science; Industry-education integration; Interdisciplinary integration

1 INTRODUCTION

The tropical crop industry stands as a cornerstone of the Southeast Asian economy, with international trade in rubber, palm oil, and tropical fruits and vegetables accounting for over 80% of the global market, intimately linked to regional economic growth and food security [1]. In the current era, a new wave of technological revolutions is propelling the industry toward digitalization, sustainability, and integration across the entire value chain. Emerging innovations such as synthetic biology, intelligent agricultural machinery, and compliance in cross-border trade are rapidly reshaping the sector, demanding multifaceted talents equipped with interdisciplinary knowledge, practical innovation capabilities, and a global perspective.

As a leading nation in tropical agricultural education and research, China boasts core production regions such as Hainan and Yunnan and has developed mature technological systems including high-yield rubber tree cultivation and disease-resistant tropical fruit breeding. Guided by the “Anji Consensus” in new agricultural science development and the Belt and Road Initiative, China’s tropical crop talent cultivation must balance domestic industrial upgrading with international collaboration. It is imperative not only to resolve longstanding challenges such as disciplinary fragmentation, disconnection between industry and education, and an overemphasis on theory at the expense of practice, but also to offer scalable educational models applicable to Southeast Asian countries. However, significant issues prevail: curriculum frameworks lag behind industrial technological advancements with insufficient interdisciplinary integration; practical instruction remains detached from production realities, the phenomenon of “learning farming only from the chalkboard”; and internationalized training lacks tailored design to meet the demands of cross-border industrial cooperation [2]. Thus, forging an innovative talent cultivation system that resonates harmoniously with industrial development has emerged as an urgent imperative for the high-quality progression of tropical crop disciplines.

2 THE CURRENT CHALLENGES IN TALENT CULTIVATION FOR TROPICAL CROP PRODUCTION MAJORS

2.1 Rigid Disciplinary Barriers and Fragmented Knowledge Systems

Traditional specialization remains excessively segmented, with curriculum frameworks anchored in single disciplines, resulting in inadequate interdisciplinary integration among agricultural engineering, agricultural science, and agribusiness. Most universities continue to emphasize conventional courses such as planting and breeding, while cutting-edge subjects like smart agriculture, cross-border trade, and green low-carbon practices constitute less than 20% of the curriculum, creating a disconnect from the industry’s demands for comprehensive, multi-dimensional value-chain development [3]. Interdisciplinary courses are often superficial, constituting mere “patchwork” assemblies lacking

systematic coverage of the entire tropical crop lifecycle, including intelligent cultivation, post-harvest processing, and international commerce. Consequently, students acquire a fragmented knowledge base ill-equipped to confront the complexity of modern industrial challenges.

2.2 Superficial Industry-Education Integration and Weak Practical Training

Collaborations between academia and enterprises remain largely perfunctory, devoid of robust, stable mechanisms for co-educational cultivation, with limited enthusiasm from industry stakeholders to engage in talent development [4]. The construction of university training bases lags behind, with 73.7% of students reporting inadequate financial support for practical teaching, alongside a dearth of smart agricultural equipment and cross-border practical platforms aligned with Southeast Asia's tropical crop production scenarios [5]. The faculty seldom embody the "dual-qualified teacher" model; 64.7% lack frontline industrial experience, impeding their capacity to effectively mentor students in resolving real-world production issues. This results in graduates possessing feeble hands-on capabilities and facing difficulties adapting to workplace demands post-graduation [6].

2.3 Insufficient International Adaptation and Deficient Cross-Border Service Competencies

Internationalized content within curricula is markedly scarce; a mere 15% of institutions offer courses related to Southeast Asian agricultural policies or international standards for tropical crops, while bilingual teaching resources remain critically insufficient. Partnerships and exchanges with Southeast Asian universities and enterprises are limited, with fewer than 10% of students afforded overseas internship opportunities. Talent cultivation schemes insufficiently incorporate regional climatic characteristics, varietal traits, and industry policy variations specific to Southeast Asia, culminating in graduates ill-prepared for transnational industrial cooperation and lacking competitive international prowess [2].

2.4 Inflexible Evaluation Mechanisms Lacking a Distinct Innovative Orientation

Current assessment systems predominantly prioritize theoretical examination results and the quantity of published papers, allocating less than 30% of the evaluation weight to practical innovation capabilities and industrial service contributions [7]. The evaluation stakeholders are narrowly defined, with minimal involvement from enterprises and industry experts, failing to objectively assess students' job competency alignment. Furthermore, evaluation timelines are disconnected from agricultural production cycles, neglecting the long-term nature of achievements in tropical crop breeding and technology dissemination. This stifles students' enthusiasm for innovation and undermines their motivation to serve the industry.

3 THE CORE ESSENCE AND FOUNDATIONAL PRINCIPLES OF THE "THREE INTEGRATIONS AND THREE DRIVES" TALENT CULTIVATION SYSTEM

3.1 The "Three Integrations": Dismantling Barriers to Forge a Synergistic Educational Ecosystem

Interdisciplinary Integration: Surpass entrenched disciplinary boundaries within agricultural sciences and the divisions among agricultural engineering, agronomy, and agribusiness. Centered on the entire tropical crop industry chain, integrate multifaceted knowledge spanning biology, information technology, and international trade to construct a comprehensive, multidisciplinary knowledge framework.

In-depth Industry-Education Integration: Fully embed authentic industry demands, production scenarios, and technical standards into every facet of talent development. Establish a collaborative triad mechanism wherein "industry poses challenges, academia devises solutions, and enterprises conduct evaluations."

Scientific-educational Synergy: Propel the transformation of national-level research platforms and major scientific projects into teaching assets, fostering a virtuous cycle between scientific innovation and talent cultivation that leverages research to enrich pedagogy.

3.2 The "Three Drives": Precision Empowerment to Activate Intrinsic Developmental Momentum

Industry Demand Driven: Align training objectives, curricula, and practical modules dynamically with the evolving demands of the Southeast Asian tropical crop sector to ensure an accurate match between talent output and industrial needs.

Cutting-Edge Technological Driven: Keep pace with frontier fields such as synthetic biology, smart agriculture, and carbon sequestration farming by integrating disruptive technologies and innovative achievements into instruction, nurturing students' scientific literacy and inventive thinking.

International Cooperation Driven: Align with the agricultural collaboration imperatives under the Belt and Road Initiative, incorporating international standards and transboundary resources to cultivate globally minded professionals adept at cross-border service.

3.3 Foundational Principles

Demand Orientation Coupled with Distinctive Development: Ground the system in the unique characteristics of tropical crop industries and regional requisites, balancing domestic industrial upgrading with international cooperation imperatives while emphasizing targeted and differentiated talent cultivation.

Integration of Knowledge Transmission and Competency Development: Consolidate solid professional foundations while intensifying the cultivation of core competencies including practical innovation and intercultural communication, achieving the harmonious unity of knowledge and action.

Harmonizing Standardization with Modularization: Construct a standardized core training framework to ensure baseline quality while devising modularized specialized content adaptable to the distinct industrial landscapes of various nations and regions.

Exemplary Leadership and Collaborative Advancement: Leverage China’s pioneering edge in tropical agricultural education to establish a replicable training paradigm, propelling coordinated development of agricultural education throughout the Greater Southeast Asian region.

4 THE CONSTRUCTIVE PATHWAY OF THE “THREE INTEGRATIONS AND THREE DRIVES” TALENT CULTIVATION SYSTEM

4.1 Curriculum System Reconstruction: Establishing a Three-Dimensional Curriculum Cluster of “Core + Modules + International”

Strengthening Core Interdisciplinary Courses: The traditional curriculum framework is reimagined to form a foundational system comprising “Tropical Crop Fundamentals + Interdisciplinary Core + Innovative Literacy”. The tropical crop fundamentals maintain essential subjects such as cultivation and breeding, thereby solidifying the professional foundation. The interdisciplinary core integrates subjects like agricultural Internet of Things, big data analytics, and cross-border trade regulations to broaden intellectual horizons. Innovative literacy is enriched with modules on critical thinking and agricultural entrepreneurship, fostering a mindset of creativity and innovation [8]. At Hainan University, the introduction of courses such as “Introduction to Smart Agriculture” and “Intelligent Crop Breeding” exemplifies the deep integration between traditional agricultural sciences and cutting-edge technologies.

Establishment of Industry-Oriented Specialized Modules: Reflecting the distinctive characteristics of Southeast Asia’s tropical crop industries, three specialized modules are designed: the Smart Cultivation Module, covering technologies such as precision irrigation and drone-based plant protection; the Green Production Module, encompassing green pest control and low-carbon cultivation; and the Industry Chain Management Module, which addresses post-harvest processing, cold chain logistics, and cross-border e-commerce. Each module comprises three to four core courses, allowing students flexibility to tailor their studies in alignment with individual career aspirations, thus realizing a personalized, competency-based educational approach.

Development of Internationally Adapted Course Resources: Bilingual textbooks such as *Introduction to Southeast Asian Tropical Agriculture* and *International Standards and Trade of Tropical Crops* are authored, incorporating content on ISO international standards and agricultural policies and regulations in Southeast Asia. Collaborative efforts with institutions including Kasetsart University in Thailand and Universiti Putra Malaysia enable the co-construction of cross-border courses and the sharing of online teaching resources, thereby enhancing students’ global perspectives and intercultural communication competencies.

4.2 Innovation in Teaching Methodologies: Implementation of a Multifaceted Approach Combining “Scenario-Based, Project-Oriented, and Cross-Border” Pedagogy

Scenario-Based Teaching to Enhance the Integration of Theory and Practice: The learning environment is extended beyond conventional classrooms to include field sites, industrial bases, and transnational practical contexts, enabling activities such as “field classrooms”, “enterprise internships”, and “cross-border study tours”. Virtual simulation laboratories are developed to replicate scenarios like intelligent tropical crop cultivation and environmentally friendly pest management, thereby reducing practical costs and associated risks.

Project-Oriented Instruction to Foster Innovative Practical Competence: Collaboration with leading enterprises and research institutions facilitates the transformation of real-world industrial projects and scientific research topics into instructional units. This approach follows a cyclical progression characterized by problem orientation, project-driven execution, competition-enhanced motivation, and eventual industrial application. Students, organized in teams, participate in projects such as tropical crop variety improvement and green production scheme design, which contribute to the refinement of their technical skills and teamwork abilities through hands-on experience.

Cross-Border Collaborative Teaching to Strengthen International Adaptability: Joint instructional teams composed of universities from China and Southeast Asia conduct hybrid online-offline cross-border education. Student involvement in industry surveys and technology dissemination within the Southeast Asian tropical crop sector serves to deepen their understanding of local industrial environments and employment requirements. Through cooperative arrangements with more than twenty Southeast Asian universities, Hainan University’s “2+2” dual-degree programs have facilitated overseas internships for over a hundred students, thereby enhancing their cross-cultural competence and professional flexibility.

4.3 Elevation of Practical Training Platforms: Establishing a Three-Tiered “On-Campus – Domestic – Cross-Border” Experiential System

Development of Distinctive On-Campus Training Bases: Leveraging university research infrastructures, specialized on-campus training facilities are established to authentically replicate Southeast Asian tropical crop production environments. These bases are equipped with state-of-the-art technologies such as agricultural Internet of Things devices, drone-based plant protection systems, and green pest control laboratories. For instance, Hainan University’s smart cultivation training base simulates the high-temperature and high-humidity conditions characteristic of Southeast Asia, thereby providing students with sustained, high-fidelity practical training opportunities.

Deepening Chinese University-Industry Collaborative Bases: Internship bases are co-developed with leading domestic entities such as the Chinese Academy of Tropical Agricultural Sciences and Hainan Rubber Group. Students undertake comprehensive internships encompassing production management and technological research and development. A dual-mentor model is implemented wherein enterprise mentors supervise hands-on operational training, while academic mentors provide theoretical guidance and foster scholarly advancement.

Construction of Cross-Border Practical Platforms: Cross-border practice bases are established in countries including Thailand, Malaysia, and Indonesia, facilitating activities such as overseas internships and technology exchanges. In partnership with prominent Southeast Asian enterprises, “Tropical Crop Technology Service Centers” are inaugurated, offering students hands-on experience in cross-border technology dissemination and industry research. These initiatives significantly enhance students’ international practical competencies and global industry insights.

4.4 Reforming the Evaluation Mechanism: Establishing a Three-Dimensional Assessment System of “Diversity + Process + Industry”

Diversification of Evaluation Content: The traditional fixation on grades and publications is transcended by encompassing theoretical knowledge, practical skills, project achievements, and contributions to industry services within the assessment spectrum. Emphasis is placed upon appraising students’ technical application proficiency, innovative thinking, intercultural communication aptitude, and dedication to the agrarian sector, thereby providing a holistic reflection of talent cultivation quality.

Process-Oriented Assessment Methods: A hybrid evaluation model combining “formative assessment (60%) and summative assessment (40%)” is implemented. Formative assessments incorporate online learning engagement, hands-on practice, project progression, and team collaboration, while summative evaluations involve practical demonstrations and project presentations. The integration of digital platforms enables comprehensive documentation of the entire learning and practice journey, enhancing objectivity and precision in appraisal.

Multiplicity of Evaluators: A multifaceted evaluation body comprising university faculty, industry experts, professional associations, and international partners is constituted. University instructors primarily assess theoretical foundations and innovative capacity; industry experts and associations concentrate on practical competencies and job-fit; international collaborators evaluate cross-border skills, collectively ensuring comprehensive and impartial evaluation outcomes.

5 PRACTICAL CASES AND ACHIEVEMENTS

Since 2020, Hainan University has embarked on the reform of its talent cultivation system under the “Three Integrations and Three Drives” framework, yielding remarkable outcomes. In terms of the curriculum system, a restructured suite of “core + modular + international” courses has been established, incorporating ten cutting-edge subjects such as smart agriculture and cross-border trade. The university has developed 26 provincial-level and above tropical specialty courses and authored 12 bilingual textbooks. Regarding pedagogical approaches, innovative teaching activities such as “field classrooms” and “cross-border study tours” have been launched. Collaborative cross-border courses have been developed jointly with more than twenty Southeast Asian universities, adopting a “project-based + blended” instructional model. On the practical training front, an on-campus smart cultivation training base has been constructed. Furthermore, synergistic talent cultivation platforms have been co-built with 74 enterprises and research institutes. Six cross-border experiential bases have also been established throughout Southeast Asia. Concerning evaluation mechanisms, a diversified, process-driven, and industry-oriented assessment system has been instituted, integrating enterprise evaluations and cross-border practice performance as core metrics.

The quality of talent cultivation has markedly improved: student practical abilities and innovative capacities have flourished, evidenced by over 90 national innovation and entrepreneurship awards and 90 SCI-indexed publications in the past three years. Graduate employment rates have consistently surpassed 95% for five consecutive years, with 40% ascending to key industry roles and 85% serving the “agriculture, rural areas, and farmers” sectors; employer satisfaction reaches an impressive 98.8%. The internationalization of training has also borne fruit, having nurtured over 200 Southeast Asian international students and trained more than a thousand technical personnel for Southeast Asian countries. The pedagogical model has been extensively acknowledged across Belt and Road nations. This system has crystallized into a replicable “Chinese paradigm”, offering a valuable reference for reform to more than ten domestic agricultural and forestry universities.

6 CONCLUSION

The innovative talent cultivation system for tropical crop production majors established by Hainan University, grounded in interdisciplinary convergence, industry-education integration, and scientific-educational synergy, and driven by industry demands, technological frontiers, and international collaboration, has effectively surmounted the prominent challenges inherent in traditional talent training paradigms. Through comprehensive curriculum restructuring, pedagogical innovation, practical enhancement, and evaluative reform, it has achieved precise alignment between talent development and the imperatives of industrial advancement, scientific progress, and global demand. This system offers valuable insights for agricultural education reform within the context of the new agricultural sciences and calls for deeper educational cooperation with Southeast Asian nations, alongside continuous refinement of cultivation models, thereby contributing China's sagacity to the sustainable evolution of global tropical agriculture.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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