

THE “CHINESE PARADIGM” OF AGRICULTURAL SCIENCE EDUCATION DRIVEN BY THE DEMANDS OF THE TROPICAL CROP INDUSTRY

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Abstract: Amid the deepening implementation of the Belt and Road Initiative and the accelerating globalization of agriculture, the tropical crop industry in Southeast Asia is undergoing a pivotal transformation from traditional extensive farming to intelligent, sustainable, and integrated industrial chain development. This evolution underscores an urgent demand for versatile, practice-oriented, and internationally innovative talents. However, conventional agricultural education models are hindered by outdated curricula, disconnected practical training, and imbalanced talent competency structures, resulting in a severe misalignment between talent cultivation and industry needs. This paper, grounded in China’s tropical agricultural education practices and the experience of new agricultural sciences development, constructs a “Chinese Paradigm” of tropical crop agricultural teaching driven by industry demand, centered on curriculum reform, and utilizing industry-education integration as its pathway. Through comprehensive iterative upgrades of the educational system, this paradigm addresses the imbalance between talent supply and demand, leveraging China’s tropical agricultural technological advantages and educational resources to develop a replicable and scalable teaching model. It offers a Chinese solution for tropical crop talent cultivation to Southeast Asian countries along the Belt and Road, embodying China’s leading exemplary role and commitment to international agricultural educational cooperation.

Keywords: Tropical crops; Industry demand; Agricultural education; Chinese paradigm; Industry-education integration; Belt and Road Initiative; Talent cultivation

1 INTRODUCTION

The tropical crop industry stands as a cornerstone sector within Southeast Asia, encompassing pivotal categories such as rubber, oil palm, coconut, and tropical fruits and vegetables. The scale of production and level of processing within this industry are intrinsically linked to regional economic advancement and the sustenance of local livelihoods. Statistics reveal that over 60% of the world’s tropical crop cultivation area resides in Southeast Asia, while products like palm oil and natural rubber constitute more than 80% of the global trade volume, underscoring the immense potential for industrial growth. In the advent of the Agriculture 4.0 era, the tropical crop sector in Southeast Asia is rapidly transitioning towards intelligent cultivation, standardized processing, and integrated industrial chain development, thereby precipitating an acute surge in demand for innovative talents proficient in advanced agronomic techniques, sustainable pest management, cross-border trade regulations, and industry management paradigms [1].

As a pivotal nation in tropical agricultural research and education, China boasts major tropical crop production zones such as Hainan and Yunnan provinces. It has cultivated a mature technological framework encompassing high-yield rubber tree cultivation, disease-resistant breeding of tropical fruits and vegetables, and green processing of agricultural products, supported by a comprehensive network of tropical agricultural research and education. Recent initiatives in the development of new agricultural sciences, including the “Anji Consensus”, the “Beidacang Action”, and the “Beijing Guidelines”, emphatically call for higher agricultural and forestry education to transcend traditional disciplinary silos and achieve synchronous resonance with industrial progress. Propelled by the Belt and Road Initiative, China’s international agricultural cooperation with Southeast Asian countries has deepened significantly, aligning both parties’ aspirations in tropical crop talent cultivation. Southeast Asian nations urgently require progressive agricultural education models to elevate the quality of their indigenous specialists, while China possesses a robust foundation in agricultural educational expertise and technological dissemination.

Nevertheless, both domestic and international programs dedicated to training professionals in tropical crop production confront common challenges: curriculum frameworks lag behind rapid technological innovations within the industry, with traditional courses predominantly focusing on basic cultivation knowledge and lacking cutting-edge content such as smart agriculture and cross-border trade; practical instruction remains detached from real-world production, hampered by outdated training bases and a prevalence of purely theoretical, “chalk-and-talk” teaching; talent competency profiles fail to meet job market demands, particularly in students’ operative skills and cross-cultural communication capabilities; moreover, there is a stark deficiency in tailor-made pedagogical systems addressing the climatic particularities, varietal traits, and policy contexts distinctive to the Southeast Asian region. Consequently, graduates struggle to meet the pragmatic needs of regional industrial development [2]. These impediments severely constrain the modernization of the tropical crop industry and impede deeper international cooperation, accentuating the

urgent necessity for a scientifically grounded, efficacious talent cultivation paradigm.

2 THE “TRIPLE DISCONNECT” BETWEEN TROPICAL CROP TALENT CULTIVATION AND INDUSTRIAL DEVELOPMENT

Contemporary tropical crop production programs urgently require nurturing multifaceted, practice-oriented, and internationally apt professionals equipped with a solid foundation in core disciplinary knowledge, mastery of smart agricultural technologies, sustainable production techniques, post-harvest processing, and cross-border trade operations. These individuals must also embody a profound commitment to the rural sector’s development alongside a global perspective, thereby aligning with the modernization, greening, and globalization imperatives of the Southeast Asian tropical crop industry [3]. Nevertheless, a pronounced misalignment persists between talent cultivation and industry demands, manifesting in a “course-to-industry”, “competency-to-position”, and “training-to-cross-border” triple disconnect.

2.1 Disjunction Between Curriculum Content and Industry Frontiers, Lacking Regional Specificity

Traditional curricula remain anchored predominantly in foundational agronomic knowledge, deficient in avant-garde subjects such as smart agriculture, eco-friendly production, and international trade. The designs of these programs have languished without substantive updates for years, starkly incongruous with the tropical crop sector’s progressive trajectory toward intelligent and green transformation. Furthermore, curricular frameworks inadequately incorporate Southeast Asia’s unique regional characteristics—including indigenous crop varietal traits, climatic and soil conditions, and pertinent industrial policies and regulations—resulting in graduates who often experience “environmental and contextual adaptation challenges” upon entering the Southeast Asian industry milieu [4]. Prevailing issues in agricultural education include an overemphasis on knowledge transmission at the expense of innovation, pronounced disciplinary silos, and insufficient interdisciplinary integration; these challenges are particularly acute in tropical crop talent cultivation.

2.2 Mismatch Between Competency Profiles and Job Market Needs, Marked by Insufficient Practical Proficiency

Industrial roles have evolved from traditional “cultivation-focused” positions toward “comprehensive practice-oriented” capacities, demanding that talents seamlessly integrate specialized expertise, hands-on operational skills, industrial management acumen, and intercultural communication finesse. Current pedagogical practices, however, exhibit a predilection for theoretical rigor over practical immersion, prioritizing academia over skill acquisition. Deficiencies such as outdated training bases, weakened school-enterprise collaborative training mechanisms, and limited experiential knowledge among educators culminate in graduates with scant practical operational competencies.

2.3 Disconnect Between Training Models and Cross-border Industrial Requirements, Reflected in Low Internationalization Levels

The curriculum packages suffer from a paucity of internationalization elements, with scarce bilingual teaching resources and limited cooperative engagement with Southeast Asian universities and research institutions. Students are consequently deprived of vital cross-border experiential learning opportunities. Moreover, talent cultivation objectives insufficiently accommodate the industrial heterogeneity across Southeast Asian nations, leading to homogenized teaching content and pedagogical approaches ill-suited to meet the diverse demands of Belt and Road cross-border agricultural cooperation. Practice within the China-ASEAN Agricultural and Forestry Education Industry-Education Integration Alliance underscores the necessity of constructing talent cultivation systems finely attuned to the regional industrial development imperatives [3].

3 THE CORE PHILOSOPHY AND FOUNDATIONAL PRINCIPLES OF THE “CHINESE PARADIGM”

3.1 Industry Demand-Driven Approach: Transitioning from a “Supply-Centered” to a “Demand-Oriented” Model

The demand-oriented educational theory underscores that pedagogical endeavors must be intricately aligned with the evolving socioeconomic landscape and the specific requisites of industrial sectors. By dynamically calibrating educational objectives, curricular frameworks, instructional content, and teaching methodologies, this approach strives to achieve a precise congruence between talent development and market demands [5]. This theoretical framework serves as the pivotal rationale for reforming tropical crop agricultural education, mandating a comprehensive alignment of teaching activities with the fluid demands of the Southeast Asian tropical crop industry. Accordingly, the dynamic needs of this industry shall be positioned as the fundamental premise for educational reform. Through continuous engagement and empirical research involving leading tropical crop enterprises, industry associations, and governmental agricultural departments, we gain accurate insights into the evolving requirements in knowledge, skills, and professional attributes, thereby reverse-engineering talent cultivation goals and curriculum design to ensure real-time

synchronization between education outputs and industrial imperatives.

3.2 Deep Industry-Education Integration: Establishing a “School-Enterprise-Research-Government” Collaborative Ecosystem

The theory of industry-education integration advocates for a profound fusion among the educational pipeline, talent development channels, industrial value chains, and innovation networks. By facilitating concerted collaboration among higher education institutions, enterprises, and government entities, this approach propels synergistic advancement in talent cultivation, industrial progress, and research innovation [6]. Given the inherently practical and applied nature of the tropical crop industry, industry-education integration constitutes the vital conduit for overcoming disjunctions in practical teaching. This entails leveraging a multifaceted alliance comprising universities, corporations, research institutes, and governmental bodies to architect a “school-enterprise-research-government” cooperative educational model, wherein authentic production environments and cutting-edge technological achievements are holistically embedded throughout the instructional process.

3.3 Constructive Principles Underpinning the “Chinese Paradigm”

The establishment of the “Chinese Paradigm” adheres to a constellation of guiding principles: harmonizing demand orientation with distinctive regional development; synergizing industry-education fusion with the integration of scientific research and education; blending disciplinary interdisciplinarity with competency-based approaches; balancing standardization with modularity; and melding exemplary leadership with collaborative advancement [7]. This principled framework not only encapsulates the core mandates of the new agricultural sciences initiative but also integrates the practical experiences accrued through Hainan University’s “Three Integrations and Three Driving Forces” talent cultivation system, thereby furnishing comprehensive guidance for the progressive upgrading of tropical crop educational systems.

4 THE CORE PATHWAYS FOR UPGRADING THE EDUCATIONAL SYSTEM

4.1 Reconstructing the Curriculum Framework: Transitioning from “Static Provision” to “Dynamic Adaptation”

A composite curriculum system integrating “core courses + specialized modules + international courses” is established, harmonizing seamlessly with Hainan University’s tri-dimensional synergistic strategy of “strategic guidance, digital intelligence empowerment, and distinctive features.” Core courses such as Tropical Crop Cultivation and Breeding are solidified to fortify students’ professional foundations. Three specialized modules—Smart Agriculture, Green Production, and Industrial Chain Management—encompass cutting-edge subjects including Agricultural Internet of Things applications, sustainable pest control technologies, and cross-border e-commerce operations. Furthermore, internationalized courses, such as *Introduction to Southeast Asian Tropical Agriculture*, *International Standards and Trade of Tropical Crops*, and *Cross-Cultural Communication in Agriculture*, are developed to broaden students’ global perspectives [8].

To ensure continual relevance, a dynamic curriculum adjustment mechanism is instituted, whereby universities collaborate regularly with agricultural enterprises to revise and update curricular content—phasing out obsolete materials and introducing forefront developments. Hainan University has thus introduced ten industry-leading courses such as “Introduction to Smart Agriculture” and “Intelligent Crop Breeding”, established 26 provincially recognized tropical-specialized courses, and authored nearly one hundred textbooks and monographs tailored to tropical crop production. These efforts realize the synchronous renewal of course content with industry advancements. In addition, region-specific modular courses are designed to address unique industrial characteristics—for example, a *Precision Management of the Palm Industry* module tailored for palm cultivation, and a *Tropical Fruit and Vegetable Preservation and Cross-Border Trade* module catering to the tropical horticulture sector.

4.2 Updating Teaching Content: Evolving from “Theoretical Instruction” to “Industry–Education Integration”

Teaching content is comprehensively enriched by embedding cutting-edge industry technologies, authentic production case studies, and regional characteristics unique to tropical zones. Advanced techniques such as cold-resistant and high-yield rubber tree cultivation, agricultural drone-based plant protection, and integrated water-fertilizer management are incorporated, enabling students to master the latest industry methodologies. Real-world cases—such as Thailand’s durian cross-border cold chain logistics and Malaysia’s palm plantation smart irrigation systems—are introduced to build a robust case study repository. Regional specificity is further enhanced by integrating knowledge of Southeast Asian varietal traits, climatic and soil conditions, and relevant industrial policies and regulations, thereby strengthening students’ adaptability across borders. Interdisciplinary knowledge fusion is emphasized by weaving big data analytics, artificial intelligence, and cross-border e-commerce concepts into specialized courses, broadening the academic horizon of learners. Hainan University implements a resource development model combining “elite courses + specialized textbooks + research monographs”, in which university faculty, enterprise technical experts, and industry specialists collaboratively author distinctive textbooks such as *Practical Guide to Intelligent Tropical Crop Cultivation* and *Green*

Production Technologies for Southeast Asian Tropical Crops. This model effectively harmonizes frontier industrial technologies with pedagogical requirements, fostering a state-of-the-art teaching and learning ecosystem.

4.3 Innovating Teaching Modalities: Transitioning from “Lecture-Based Instruction” to “Contextualized Education”

A hybrid pedagogical model is established, integrating “online autonomous learning with offline contextualized instruction.” An extensive online resource repository for tropical crop disciplines is constructed, encompassing bilingual theoretical lecture videos, practical training guides, cutting-edge industry updates, and virtual simulation experiments, enabling learners to engage in fragmented, self-paced study via digital platforms. Concurrently, immersive, scenario-based teaching activities are conducted, including field classrooms, on-site base instruction, and enterprise internships, effectively extending the learning environment to frontline production settings. Project- and task-based teaching methodologies are employed, incorporating authentic industry projects such as “Design of Green Production Schemes for a Southeast Asian Rubber Plantation”, thereby cultivating students’ pragmatic problem-solving competencies [10]. A virtual simulation laboratory is also developed to replicate the entire tropical crop production process, significantly mitigating the costs and risks associated with physical experiments. This approach draws upon experiment-centric blended learning philosophies [11], enhancing pedagogical efficacy through reinforced practical engagement, while embedding a closed-loop cultivation pathway characterized by “problem orientation → project-driven learning → competition empowerment → industrial application”.

4.4 Elevating Practical Training: From “Isolated Skill Drills” to “Comprehensive Full-Chain Integration”

A comprehensive, full-chain practical training system is constructed, encompassing “on-campus training—domestic industry base internships—transnational Southeast Asian field practice.” On-campus training bases, aligned with Southeast Asian production scenarios, are equipped with advanced implements such as agricultural IoT devices and drone-based plant protection platforms. Collaboration with leading domestic tropical crop enterprises and internationally engaged agricultural companies is deepened, establishing stable off-campus internship bases and facilitating student positions for hands-on work experience. Cross-border practical bases are established in key Southeast Asian production countries—for example, tropical fruit and vegetable practice centers in Thailand and palm industry bases in Malaysia—enabling students to engage in transnational internships and scientific research collaborations. An integrated mechanism synergizing “practical training—competitive contests—innovation and entrepreneurship” is developed, organizing student participation in events like the National College Agricultural Innovation and Entrepreneurship Competition to stimulate learning and training through competition [12]. Hainan University actively leverages its experience in granting undergraduates panoramic access to 28 provincially and nationally recognized research platforms—such as key national laboratories—thus forging a profound integration of research and practice that heightens students’ hands-on capabilities in authentic scientific settings. Presently, the university has jointly established cooperative education platforms with 74 entities, including the Yazhou Bay National Laboratory and Hainan State Farms Investment Holding Group, cultivating a seamless “education–research–industry” ecosystem that transforms scientific and industrial resources into rich teaching assets.

4.5 Strengthening the Faculty: Transitioning from “Solely Academic” to “Dual-Qualified and Internationalized”

A comprehensive faculty development mechanism is established, integrating “on-campus training, external recruitment, and international exchange.” Emphasis is placed on cultivating dual-qualified instructors within the university, mandating that specialized faculty undertake no less than six months of enterprise secondment every three years to amass practical experience. Concurrently, considerable efforts are devoted to recruiting industry experts as adjunct faculty, forming a triadic, synergistic teaching cohort comprised of “distinguished on-campus professors, eminent scholars, and industry mentors.” Key faculty members are dispatched to Southeast Asian universities for academic exchange visits to enhance their global pedagogical competencies. Cross-border teaching teams are assembled, uniting educators from Southeast Asian institutions with technical professionals from enterprises to collaboratively engage in instructional research and practical guidance. Additionally, the faculty evaluation system is reformed to incorporate metrics such as student research mentorship and competition involvement into performance assessments, incentivizing educators to actively translate their research expertise into pedagogical resources, thus fostering a virtuous cycle whereby research enriches teaching and teaching advances research.

4.6 Refining Assessment and Evaluation: From “Single Grades” to “Holistic Competency”

A diversified evaluation framework is constructed, guided by industry demands and centered on holistic student competencies. Assessment criteria encompass a broad spectrum, including theoretical knowledge, hands-on skills, project design capabilities, teamwork, and intercultural communication, enabling a comprehensive appraisal of students’ overall aptitude. A combination of formative and summative assessments is employed, with formative evaluations constituting no less than 60% of the total, covering aspects such as online learning engagement, practical operations, and project work. The evaluation body is pluralistic, comprising teachers, enterprise representatives, industry experts, as well as peer and self-assessments from students, ensuring objectivity and applicability of results. Job-specific assessment standards are devised, precisely aligned with occupational requirements in Southeast Asian industries.

5 DEMONSTRATION AND DISSEMINATION MODEL OF THE “CHINESE PARADIGM”

The “Chinese Paradigm” presents an indigenous solution for tropical crop talent cultivation tailored to Southeast Asian countries along the Belt and Road Initiative, exemplifying China’s commitment and responsibility within the realm of agricultural education. This paradigm effectively addresses the acute talent scarcity hindering the modernization and transformation of tropical crop industries in Southeast Asia, empowering these nations to elevate the quality of their domestic agricultural education and workforce. Furthermore, it fosters deepened international cooperation in agricultural education between China and Southeast Asian countries [3]. The cross-border dissemination of this paradigm is propelled through a multifaceted synergy of approaches, including the exportation of curricular resources, establishment of collaborative inter-university partnerships, provision of technical training and academic workshops, as well as coordinated promotion through school-industry alliances.

6 PRACTICAL CASE STUDY — HAINAN UNIVERSITY AS AN EXEMPLAR

Hainan University, a “Double First-Class” institution situated in China’s tropical region, leverages the strategic opportunities presented by the Hainan Free Trade Port and the Belt and Road Initiative. Driven by the demands of Southeast Asia’s tropical crop industry, it has proactively explored and constructed the “Chinese Paradigm” for tropical crop agricultural science education, with its practical experiences providing pivotal support for the continual refinement of this model.

Regarding curriculum development, the university has restructured its offerings into a composite system comprising “core courses, specialized modules, and international curricula”, aligned closely with the predominant industries of rubber, oil palm, coconut, and tropical fruits and vegetables in Southeast Asia. A tri-dimensional synergistic approach—characterized by strategic guidance, digital-intelligent empowerment, and distinctiveness—has been implemented. In this framework, ten cutting-edge courses, including “Introduction to Smart Agriculture” and “Intelligent Crop Breeding”, have been introduced to keep pace with industry frontiers. Furthermore, a practical training platform centered on a “large-scale biological breeding model” has been established. Building upon the solid foundation of core subjects such as tropical crop cultivation and breeding, the university has developed internationally oriented courses like *Overview of Southeast Asian Tropical Agriculture*, *International Standards and Trade of Tropical Crops*, and *Cross-Cultural Communication in Agriculture*, supported by a dynamic curriculum adjustment mechanism. To date, Hainan University has developed 26 provincial-level and above tropical specialty courses and authored nearly one hundred textbooks and monographs related to tropical crop production disciplines.

In terms of industry-education integration, Hainan University has deepened its collaborative ties with key research institutes and enterprises such as the Chinese Academy of Tropical Agricultural Sciences, Hainan Rubber Group, and China National Agricultural Development Group, establishing a “university–research–enterprise” synergistic talent cultivation mechanism. Authentic industrial projects and real-world production cases are thoroughly embedded within the teaching framework, promoting project-based and case-based pedagogies. On-campus practical training bases specializing in rubber, coconut, and tropical fruits and vegetables have been developed, while 28 national and provincial-level research platforms—including national key laboratories—are comprehensively accessible to undergraduates, facilitating profound integration of research capabilities with educational resources. Currently, the university has co-founded collaborative talent cultivation platforms with 74 entities such as the Yazhou Bay National Laboratory and Hainan State-Owned Agricultural Investment Holdings Group, forging an integrated ecosystem that seamlessly connects teaching, research, and industry.

In faculty development, the university implements a “dual-qualification” training program mandating that professional instructors undertake secondments in enterprises or frontline production sites for no less than six months every three years. Twelve seasoned industry experts from domestic tropical crop enterprises and Southeast Asian agricultural research institutions have been recruited as adjunct lecturers, forming an external mentorship cohort. Over twenty core faculty members have been dispatched to Southeast Asian universities such as Kasetsart University in Thailand and Universiti Putra Malaysia for academic visits and exchanges to enhance their international pedagogical competencies. Concurrently, the institution has reformed its faculty evaluation system to incorporate metrics such as student research supervision and competition involvement into teacher performance appraisals.

Regarding value education, Hainan University continually excavates indigenous cultural assets such as the “Nanfan Story” and the “Rubber Tree’s Northern Migration Miracle” to construct a triadic ideological and political education case repository comprised of “pioneering professional narratives, instructors’ practical case studies, and alumni development trajectories.” This initiative aims to cultivate students’ genuine dedication to serving agriculture, rural areas, and farmers, internalizing this commitment in their minds and manifesting it through their actions.

Through the iterative refinement of its educational framework and the pioneering implementation of the “Chinese Paradigm”, the Tropical Crops College of Hainan University has witnessed a remarkable enhancement in the quality of talent cultivation. Students’ practical proficiencies and global perspectives have been markedly strengthened, culminating in the attainment of over 90 national-level innovation and entrepreneurship awards and the publication of 90 SCI-indexed research papers. The graduate employment rate has consistently exceeded 95% for five consecutive years, with 40% of alumni evolving into industry pillars. The proportion of undergraduates pursuing postgraduate studies has surged from 15% to 50%, and employer satisfaction has reached an impressive 98.8%. A substantial number of graduates have secured positions within Southeast Asia’s international agricultural enterprises, research institutions,

and cross-border cooperative projects, emerging as the vanguard driving the sustainable development of the tropical crop industry along the Belt and Road. Noteworthy alumni such as the “National Model Worker” Xing Fufu, the “Pomelo Couple” An Shuoyu and Huang Xiaoling, and the “Rural Revitalization Leader” Lin Jianle exemplify this success. These achievements robustly affirm both the feasibility and efficacy of the “Chinese Paradigm”.

7 CONCLUSION AND OUTLOOK

The “Chinese Paradigm” of agricultural science education, driven by the demands of the tropical crop industry constructed in this study, harnesses industrial needs as its guiding axis, employs industry-education integration as its strategic pathway, and places curriculum reform at its core. This comprehensive approach systematically addresses the prevalent disconnect between talent cultivation and industry development within the tropical crop sector. By assimilating the fundamental principles of the new agricultural sciences framework and leveraging the practical experience of Hainan University’s “Three Integrations, Three Drives” talent development system, the paradigm achieves precise alignment between educational outcomes and industrial requirements through a multifaceted strategy encompassing curriculum restructuring, content modernization, pedagogical innovation, enhancement of practical training, faculty development, and refinement of assessment mechanisms.

COMPETING INTERESTS

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

ACKNOWLEDGMENT

The work was financially supported by Key Project of 2026 Hainan Provincial Higher Education Institution for Education and Teaching Reform: Construction and Practice of an Undergraduate-Graduate Articulated Top Innovative Talent Training System under the Background of New Agricultural Sciences.

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