出國報告（出國類別：開會）

赴史瓦帝尼王國技術交流並參加「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」

服務機關：農業部臺中區農業改良場
姓名職稱：林煜恒副研究員

派赴國家：史瓦帝尼王國
出國期間：114年8月16日至8月24日
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赴史瓦帝尼王國技術交流並參加「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」

出國報告書

目錄

壹、 摘要

為深化臺灣與友邦間的農業技術合作與知識交流，本(114)年應亞蔬－世界蔬菜中心邀請，並在農業部經費支持下，於 8 月 16 日至 8 月 24 日前往史瓦帝尼王國，參與「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」擔任講師。本次出訪為「臺灣非洲蔬菜倡議（Taiwan Africa Vegetable Initiative, TAVI）」合作計畫之一，旨在分享臺灣於有機蔬菜栽培管理、病蟲害綜合防治（IPM）及採後處理之經驗與技術，協助史國強化蔬菜產業能量與人才培育。出訪期間除參與研討會與培訓課程外，亦與當地農業部及女農基金會交流，實地拜訪標竿農民與學校午餐計畫，瞭解原生蔬菜發展現況與生產挑戰。史國蔬菜產業雖具發展潛力，惟受乾旱、病蟲害及技術不足限制，需加強技術導入與在地化應用。本次任務促進雙邊農業技術交流，深化臺史合作基礎，並建議持續推動示範田建立、種子教師培訓及原生蔬菜研究，發展非洲地區永續蔬菜產業之合作模式。

貳、 前言

為促進我國農業技術之國際交流與合作，並強化與非洲友邦在蔬菜產業發展上的夥伴關係，臺中區農業改良場林煜恒副研究員於 114 年 8 月 16 日至 8 月 24 日，在農業部支持下，應亞蔬－世界蔬菜中心邀請，前往史瓦帝尼王國參與「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」並擔任講師。本次任務屬「臺灣非洲蔬菜倡議（Taiwan Africa Vegetable Initiative, TAVI）」合作計畫之一，旨在透過技術分享與人才培育，協助提升非洲地區蔬菜生產能力與糧食安全，並推廣健康飲食與蔬菜消費文化。出訪期間除講授臺灣於有機蔬菜栽培管理、病蟲害綜合防治（IPM）及採後處理技術之經驗外，亦與史國農業部及女農基金會進行深度交流，實地訪查當地蔬菜生產現況與挑戰。期透過本次出訪，深化臺灣與史瓦帝尼在農業領域之合作基礎，亦有助於推動原生蔬菜的復育與應用，並為未來在非洲地區擴展永續蔬菜生產合作奠定良好基礎。

參、 目的

亞蔬－世界蔬菜中心近年來與臺灣農業部、外交部及史瓦帝尼農業部密切合作，推動「臺灣非洲蔬菜倡議（Taiwan Africa Vegetable Initiative, TAVI）」。此計畫旨在提升非洲各國蔬菜生產能力，改善糧食多樣性，並強調蔬菜營養價值，以促進當地民眾健康飲食習慣與蔬菜消費文化的建立。此次受亞蔬-世界蔬菜中心邀請，並在農業部支持下前往史瓦帝尼王國，主要任務是參與並擔任「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」講師，藉由專題講授與實務經驗分享，向史國農業部及相關單位的推廣人員介紹我國在有機蔬菜栽培管理、病蟲害綜合防治以及蔬菜採收後處理等方面的先進技術與成功案例。期望透過本次講習會，不僅傳遞知識，更能培訓一批具備專業能力的種子教師，協助強化當地農業技術能量。

肆、 出國人員

林煜恒 副研究員/農業部臺中區農業改良場

伍、 出國行程

Date 日期	Activity 活動
August 16-17	Travel from Taiwan to Eswatini 從臺灣前往史瓦帝尼
August 18	Participating in a mini-workshop with officers from the Ministry of Agriculture, Eswatini 與史瓦帝尼之農業部官員舉行小型研討會
August 19	Visiting the fields of champion farmers 考察標竿農民的田區
August 20	Conducting a session as part of the Smart Tunnel Production program organized by the Taiwan Embassy 為臺灣大使館辦理的智慧隧道生產計畫授課
August 21-22	International Training Workshop on Environmentally Sustainable Vegetable Production, Pest Management, and Post-Harvest Practices 環境永續之蔬菜生產與病蟲害管理以及採後處理技術之國際培訓研討會
August 23-24	Travel from Eswatini to Taiwan 自史瓦帝尼返回臺灣

陸、 工作內容

一、與史國農業部官員會議討論在地農業發展及需求

史瓦帝尼王國（Kingdom of Eswatini，舊稱史瓦濟蘭）位於非洲南部，國土面積約 17,364 平方公里，人口約 120 萬人，是非洲少數實行君主立憲制的國家之一。地形由西向東自高地逐漸過渡至低地，海拔變化顯著，形成多樣的氣候條件。全國屬亞熱帶氣候，年降雨量因地勢而異，高地區雨量充沛、低地則偏乾燥，乾旱為主要氣候風險。這樣的自然環境雖提供農業多樣化的可能，但同時也使農業生產受氣候變遷影響甚鉅。

農業為史國的主要經濟支柱，約七成人口從事農業相關生產，農村多以自給自足型小農為主。主要糧食作物包括玉米、高粱、豆類及根莖類作物，其中玉米為最重要的主食。然而，因土地肥力下降、氣候變遷造成降雨不穩，加上灌溉系統與農機具不足，糧食產量常無法滿足國內需求。除糧食作物外，該國亦發展甘蔗、柑橘及林木等經濟作物，其中甘蔗產業在出口貿易中占有關鍵地位，柑橘則以出口歐洲市場為主，展現一定競爭力。儘管如此，整體農業生產仍面臨氣候風險高、勞力不足與技術落差等挑戰。

臺灣與史國自 1968 年建交以來，長期維持友好合作關係。臺灣在農業援助上扮演重要角色，協助該國推廣水稻與蔬菜栽培、果樹管理、灌溉技術及農業人才培訓，顯著提升農業生產效率與糧食自給率。近年來，亞蔬－世界蔬菜中心亦透過「臺灣非洲蔬菜倡議（Taiwan Africa Vegetable Initiative,

TAVI）」計畫，結合我國農業部、外交部與史瓦帝尼農業部資源，致力推動非洲傳統蔬菜的保育、生產與消費，強化當地永續農業體系。

為使本次「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」內容更貼近當地需求，於 8 月 18 日，在亞蔬－世界蔬菜中心安排下，與史國農業部官員及技術人員召開會議，針對史瓦帝尼當前農業發展現況及蔬菜產業挑戰進行深入討論。會議中，史方代表明確指出，氣候變遷造成的高溫與乾旱已成為影響蔬菜生產的主要瓶頸，許多農業生產區域皆常因灌溉水源不足導致作物生長受限，生產穩定性降低。此外，病蟲害發生頻率逐年增加，防治難度亦隨之提升，當地農民在病蟲害防治資材及有機肥料選擇上資源有限，缺乏安全有效的替代方案，導致農藥使用頻繁且缺乏管理。

在會議中，史方特別表達希望能建立針對主要蔬菜的綜合病蟲害管理（Integrated Pest Management, IPM）制度，透過示範與培訓，協助農民減少農藥依賴並提升永續生產力。此外，史國官員也指出，蔬菜採收後的分級、包裝、冷藏與加工能力明顯不足，常因儲藏條件不佳造成大量損耗。缺乏穩定的冷鏈系統與市場銷售通路，使農民收益受限。另在種子生產與保存方面，當地尚缺乏適用的技術規範與設備，導致種原更新不易，也限制了蔬菜產業的持續發展。

針對上述問題，雙方在會中討論未來合作方向。首先，建議由臺灣與亞蔬中心共同協助規劃適合當地氣候的蔬菜品種試驗與選拔，推廣耐熱、抗旱及抗病蟲害之品系。其次，透過「種子教師（trainer of trainers）」制度，強化地方農業技術員之培訓能量，以建立自我推廣與輔導系統。第三，建議導入簡易型採後處理與冷藏技術示範，協助提升蔬菜品質與市場競爭力。最後，雙方一致認為應加強原生蔬菜的研究與推廣，發掘其營養價值與市場潛力，作為提升糧食多樣性與永續農業的重要途徑。

本次會議充分展現史國對蔬菜產業發展的重視，也凸顯臺灣農業技術在協助非洲友邦強化農業能力建設上的關鍵作用。透過具體合作與持續交流，未來可望在史瓦帝尼建立以技術示範、人才培訓與在地化應用為核心的蔬菜產業發展模式，深化雙邊夥伴關係，並為推動非洲地區永續農業發展奠定長遠基礎。

圖 1、與史國農業部官員進行該國農業現況及需求討論	圖 2、會議後與史國農業部官員互動認識並進行合照

二、拜訪史國標竿農民田區

為深入瞭解史國目前蔬菜生產現況及農民實際面臨的栽培挑戰，8 月 19 日在亞蔬－世界蔬菜中心安排下，前往當地具代表性的兩戶標竿農民田區進行實地訪查與交流。透過觀察其田間管理方式、肥培制度及銷售模式，並與農民面對面討論栽培困境與改進方向，期能掌握該國蔬菜生產體系之現況，作為未來技術合作與教育培訓計畫的參考依據。

第一戶拜訪的農民為位於 Malkerns 地區的 Make Dudu Dlamini 女士。她以多元經營與永續理念著稱，長期致力於推廣原生蔬菜生產與營養教育。其農場採取芒果與非洲原生蔬菜間作的模式，不僅可有效提升土地利用率，亦能藉由樹蔭調節田間微氣候，減輕高溫與乾旱對作物生長的衝擊。主要栽培的蔬菜包含非洲芥藍（African kale）、非洲茄屬蔬菜（African nightshade, 當地稱 Umsobo）及莧科蔬菜（Amaranthus, 當地稱 Imbuya），皆為當地居民長期食用且具營養價值的傳統作物。

Dlamini 女士全程採用有機農法進行生產管理，施肥以牛糞堆肥為主。其表示，牛糞堆肥在史國來源穩定、價格低廉，亦能改善土壤有機質含量與保水能力。其栽培之各類作物面臨不同病蟲害挑戰：非洲芥藍常受蚜蟲危害，造成葉片捲曲與生長遲緩；非洲茄屬蔬菜易感染白粉病，影響葉面品質與採收量；莧科蔬菜則因低溫誘導抽花現象而降低產量。為減少化學農藥使用，她嘗試利用植物萃取液與田間輪作方式進行防治，但仍缺乏系統化技術支援。

該農場的原生蔬菜採連續採收模式，每週可採收 3 天，可持續採收二至三個月。收穫後的蔬菜主要供應鄰近學校營養午餐計畫，每週可供應 40 至 60 公斤，售價折合新臺幣約每公斤 40 至 50 元。此生產模式不僅為 Dlamini 女士提供穩定的家庭收入，也使學童能在校園中獲得新鮮、安全且營養豐富的蔬菜來源，兼具社會與教育價值。同時，這樣的行動讓原生蔬菜重新走入日常飲食，帶動社區對本土作物的重新認識與重視，展現農業生產與公共健康間的正向連結。

第二處拜訪的農場位於史國東北部 Nkalashane, Lomahasha 地區，由從事蔬菜生產逾三十年的 Maziya 夫婦經營。自 1988 年起，他們便投入甘藍、番茄與芥菜等蔬菜作物栽培，具備豐富的農業經驗。近年在「臺灣非洲蔬菜倡議（Taiwan Africa Vegetable Initiative, TAVI）」計畫推動下，他們開始導入非洲芥藍、非洲茄屬蔬菜與莧菜等傳統作物的栽培技術。透過亞蔬中心與教育培訓部的協助，其農場成為原生蔬菜示範田，並將生產的蔬菜納入學校供餐體系。

目前 Maziya 夫婦的原生蔬菜供應超過 700 名學童的營養午餐使用，為當地學校提供穩定的蔬菜來源。這些蔬菜的導入不僅豐富了學生飲食結構，也改善了學童營養攝取與健康狀況，進而促進學習專注力與學業表現。

Maziya 夫婦同時將部分蔬菜產品銷售至地方市場與餐飲業，逐步形成兼具社會責任與商業價值的永續生產模式。

值得一提的是，他們亦嘗試以小規模加工與包裝方式提升產品附加價值，並指導其他農民學習栽培與田間管理技術，促進地方農民組織形成。透過技術共享與示範帶動效應，原生蔬菜生產逐漸由小農自用轉向商業化發展。Maziya 夫婦目前已成為該地區公認的標竿農民，其成功經驗鼓舞了更多農友投入原生蔬菜栽培與販售，形成可持續的農業社群網絡。

綜合兩戶農民的訪查結果可見，史國原生蔬菜生產體系雖仍處於發展初期，但其在營養、環境永續及社會效益方面展現高度潛力。當地農民普遍具備保育傳統作物與推廣健康飲食的意願，惟在有機病蟲害管理、肥培技術與採後處理等環節仍需外部技術支援。建議未來持續透過「臺灣非洲蔬菜倡議」計畫強化技術示範與教育訓練，協助建立以在地原生蔬菜為核心的永續生產模式，並串聯市場與學校供餐體系，以創造兼顧經濟收益與公共福祉的農業發展典範。

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三、史國女農基金會及「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」授課

為強化史國蔬菜產業的永續發展能力，目前臺灣農業部及外交部與史瓦帝尼女農基金會（Women Farmers Foundation of Eswatini）合作推動「智慧隧道生產計畫」，協助該國建立以塑膠布溫室為主的隧道式栽培設施。此計畫的推行旨在降低極端氣候對農業生產造成的衝擊，提供穩定的生產環境，並同時提升當地農民在病蟲害管理及有機栽培上的技術能力。女農基金會成員對此計畫表達高度期盼，認為「智慧隧道」能使蔬菜生產更加穩定

並兼顧環境永續，成為結合科技導入與在地需求的成功案例，也是臺灣農業技術援助在非洲地區落實的具體成果之一。

為深化合作成果與推動技術落地，8 月 20 日於女農基金會舉辦「有機蔬菜生產及採收後處理技術」課程，共有 45 位學員參與，成員包含基金會農民代表、農業技術員及地方農業推廣人員。課程內容著重於有機肥料應用、綜合病蟲害管理、採收後品質維護及小規模加工保存等實務主題，並以臺灣推動環境永續蔬菜生產的經驗為案例，介紹如何以低投入、循環式管理模式達成高品質生產。學員們對於臺灣在設施環境控制、病蟲害預警與資材使用的實務經驗表現出高度興趣，並積極討論如何將這些技術應用於當地現有條件中。

隨後於 8 月 20 日至 21 日，辦理「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」，針對史國四個主要地區的農民與農業推廣官員共 40 名學員進行授課。研討會內容延續前述課程主軸，並更著重於區域性生產問題的技術應對，例如在乾旱地區如何運用滴灌及覆蓋技術維持土壤濕度，或在高溫季節如何透過作物種類及品種選擇、設施與遮陰網降低作物熱逆境。課程亦特別強調病蟲害監測的重要性，介紹臺灣推行的 IPM 模式，包括誘蟲監測、物理防治、天敵利用及減少化學農藥依賴的策略。

在採收後處理方面，課程示範了簡易分級、清洗與包裝流程，說明溫度控制與儲運管理對蔬菜品質維持的重要性。史國多數農民在這方面仍欠缺經驗與設備，學員對此表示課程內容極具實用性，並期望未來能在政府與國際合作支持下逐步導入相關技術。課程最後，學員們針對如何整合有機生產與市場行銷提出交流與構想，顯示史國農業正從基礎生產逐步邁向品質與永續並重的方向發展。

本次授課與研討活動不僅促進了技術知識的交流，更強化了臺灣與史國在農業教育與能力建構上的連結。透過此次合作，當地學員對有機農業生產管理及採後技術有了更完整的理解，並表示將所學應用於實際輔導與田間生產中。此培訓成果將有助於史國蔬菜產業的長期發展，也為未來臺灣與非洲各國在農業技術推廣及永續發展合作奠定良好基礎。

圖 13、女農基金會舉辦「有機蔬菜生產及採收後處理技術」課程全體參與人員合照。

圖 14、於女農基金會「有機蔬菜生產及採收後處理技術」課程授課

	
圖 15、「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」全體參與人員合照	圖 16、亞蔬-世界蔬菜中心史瓦帝尼辦公室詹淵理博士為「環境永續蔬菜生產及病蟲害與採後處理技術國際培訓研討會」進行開場致詞

柒、 心得與建議

一、在地化調整及政府、研究與農民的多方連結

史瓦帝尼蔬菜生產所面臨的挑戰，與世界各國農業普遍遭遇的困境相似，如氣候變遷導致的高溫與乾旱、病蟲害的頻繁發生，以及有機資材與技術不足等問題。然而，雖問題具共通性，解決方案卻必須因地制宜，並隨著當地環境條件、資源可得性及農民需求進行彈性調整。農業技術的移轉不能僅依靠單一國家的經驗，而是需要在地化的實踐與修正。要有效因應這些挑戰，除農民本身努力之外，更需多方單位的合作與協調。政府部門、研究機構、推廣人員與農民之間應建立更緊密的合作機制。農業推廣人員作為技術與農民的橋梁，應積極將研究成果轉化為農民可操作的管理模式；而農民也需要主動反饋實際生產中的困難與需求，透過雙向交流，才能共同尋求最適合的解決方針。

建議：

1.因地制宜的技術示範：協助史瓦帝尼建立試驗示範田，針對當地氣候條件進行有機蔬菜栽培、節水灌溉與綜合病蟲害管理技術的示範與調整，提升技術在地化的可行性。

2.培訓與種子教師養成：持續辦理蔬菜生產、病蟲害防治及採後處理的實務訓練，培養當地推廣人員與種子教師，形成在地自我延續的能力。

3.有機資材研發與推廣：引進並協助改良當地利用畜牧副產品與植物副產物製作有機質肥料或利用自製植物萃取液作為病蟲害防治資材，建立循環利用、低成本且易於取得的資材模式。

4.數位農業輔導工具：開發簡易化的數位資訊平台（如手機應用程式或簡訊服務），提供農民即時的栽培管理指引與病蟲害預警，提升技術普及率。

5.國際合作橋梁：善用與世蔬及臺灣外交部的合作經驗，協助串聯國際資源，推動跨國農業技術交流，擴大影響力與資源共享。

二、原生蔬菜開發潛力、從種質庫建立到區域合作網絡

原生蔬菜在面對氣候變遷與資源限制時展現出更高的適應性與潛力，例如非洲芥藍、茄屬蔬菜及莧科蔬菜，不僅耐逆境且具營養價值，若能納入主流農業體系，將有助於提升糧食安全與飲食多樣性。非洲蘊含豐富的蔬菜種質資源，但相關研究及推廣仍需強化。對臺灣而言，過去與非洲蔬菜產業連結有限，但透過國際合作與種質引進，可開拓熱帶與亞熱帶農業研究新視野，並推動新興蔬菜市場發展。農業的永續發展仰賴跨國共享資源、優勢互補與技術合作，臺灣在此過程中能發揮積極影響力。

建議：

1.深化與世界蔬菜中心的原生蔬菜合作：共同建立原生蔬菜種質庫，進行耐熱、耐旱及抗病蟲性狀的評估，並挑選具商業潛力的品種進行試驗栽培。可針對非洲蔬菜在臺灣環境的適應性進行研究，累積栽培技術經驗。並與亞蔬合作發展原生蔬菜的營養分析與加工利用研究，將其價值提升至食材開發與保健應用層次。

2.加強非洲各國的蔬菜合作：藉由世蔬中心、農業部及外交部所合作之「臺灣非洲蔬菜倡議（Taiwan Africa Vegetable Initiative, TAVI）」，推動「技術示範農場」，在非洲建立示範田區，擴散本倡議成效在蔬菜栽培、病蟲害管理及採收後處理的成功案例。

3.持續協助培訓「種子教師」，針對非洲當地推廣人員與農友辦理實務課程，促進技術在地化並強化知識傳遞。

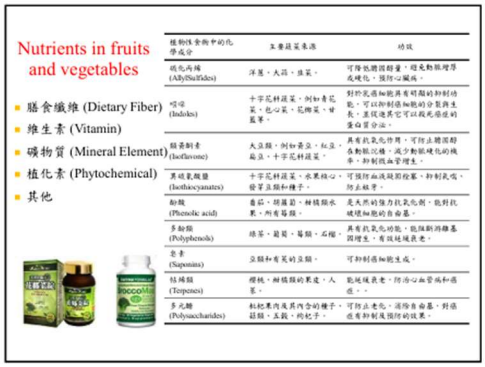
4.發展「雙向交流機制」：鼓勵非洲研究人員至臺灣進行短期訓練與交流，同時定期派遣臺灣專家赴非洲世蔬中心據點進行短期駐點教學並蒐集關於非洲蔬菜產業資訊，並協助進行蔬菜產業輔導工作。

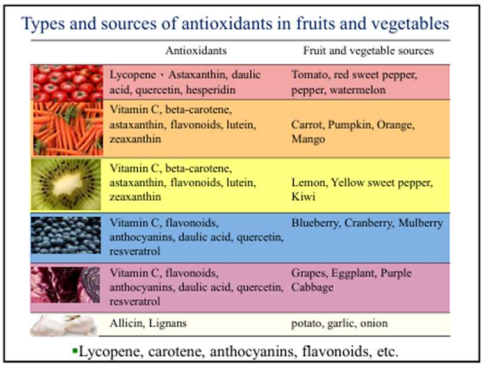
5.擴大「區域合作網絡」：以史瓦帝尼為合作示範據點，逐步串聯其他非洲國家，推動跨國蔬菜技術合作與市場鏈結。

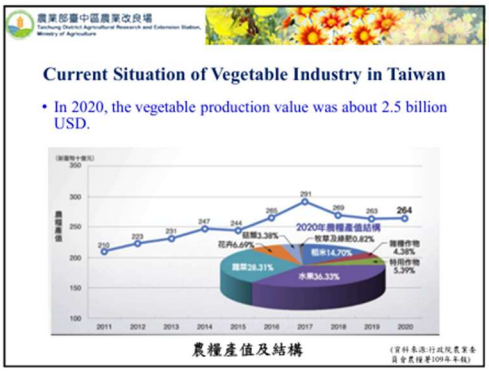
捌、 附錄

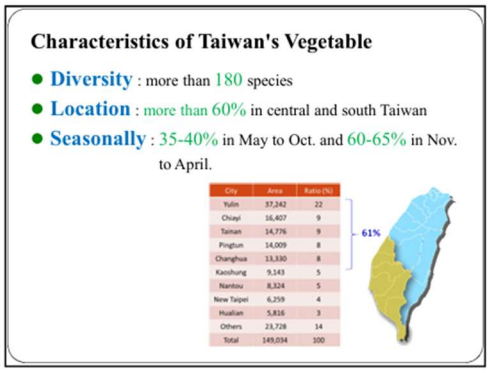

農業部臺中區農業改良場
Organic Vegetable Cultivation Management and Integrated Disease and Insect strategies
Yu-Heng Lin
Vegetable laboratory
Taichung District Agricultural Research and Extention station, Minstry of agriculture


What is Vegetable?
Vegetables are the food we eat every day.
Vegetables have different shapes, colors, smells, and taste.
A broad definition of vegetables, that is, where plants are usually soft, crisp, fleshy, juicy or have a special smell, etc., whether they are roots, stems, leaves, flowers, fruits, seeds or fungi, they can be used for meals and non-staple food or seasoning is called.


Nutrients in fruits and vegetables
膳食纖維 (Dietary Fiber)
維生素 (Vitamin)
礦物質 (Mineral Element)
植化素 (Phytochemical)
其他


Types and sources of antioxidants in fruits and vegetables
Antioxidants
Fruit and vegetable sources
Lycopene、Astaxanthin, daulic acid, quercetin, hesperidin
Tomato, red sweet pepper, pepper, watermelon
Vitamin C, beta-carotene, astaxanthin, flavonoids, lutein, zeaxanthin
Carrot, Pumpkin, Orange, Mango
Vitamin C, beta-carotene, astaxanthin, flavonoids, lutein, zeaxanthin
Lemon, Yellow sweet pepper, Kiwi
Vitamin C, flavonoids, anthocyanins, daulic acid, quercetin, resveratrol
Blueberry, Cranberry, Mulberry
Vitamin C, flavonoids, anthocyanins, daulic acid, quercetin, resveratrol
Grapes, Eggplant, Purple Cabbage
Allicin, Lignans
potato, garlic, onion
Lycopene, carotene, anthocyanins, flavonoids, etc.


農業部臺中區農業改良場
Current Situation of Vegetable Industry in Taiwan
In 2020, the vegetable production value was about 2.5 billion USD.
2020年農糧產值結構
農糧產值
農糧產值及結構


Characteristics of Taiwan's Vegetable
Diversity : more than 180 species
Location : more than 60% in central and south Taiwan
Seasonally : 35-40% in May to Oct. and 60-65% in Nov. to April.
61%

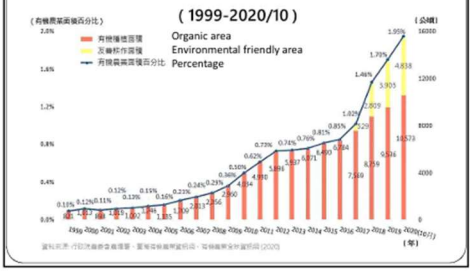

農業部臺中區農業改良場
Farming methods
Conventional farming
Organic farming


農業部臺中區農業改良場

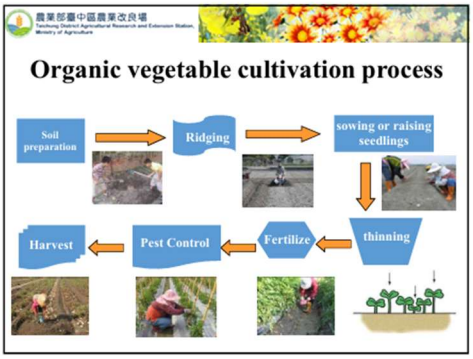
Pesticide residues

- Residues of pesticides, chemical fertilizers, animal medicines, and plant and animal hormones endanger food safety and human health.
- According to research, **only about 1% of the pesticides sprayed during farming actually enter the target insects or bacteria**, while the rest are scattered in the air, soil, rivers and remain on vegetables.
- The percentage of residues on vegetables is as high as 45%. Some of the chemicals that remain on crops can harm health after entering the human body.

Growing organic cultivated area in Taiwan



Organic vegetable cultivation process



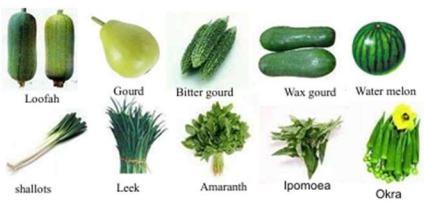
Organic farming plan

Umbelliferae vegetables are prone to continuous cropping problems

Clubroot of Cabbage

- Temperature 18-25℃、<PH 5.5.
- Adding $CaCO_3$ during soil preparation can increase the pH value of the soil.
- Bacillus subtilis treatment

Summer vegetable

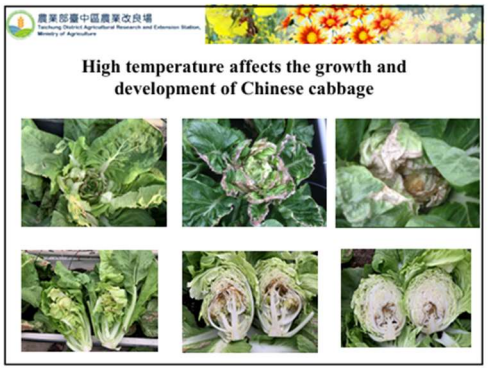



Tai Nong No.57
Tai Nong No.66
Tai Nong No.73


栗子瓜
地瓜


Basella alba L.
Portulaca oleracea
蕹菜
馬齒莧 purslane
非洲茄藍
Indigenous Vegetable
蔓用萬苣
紫蘇 perilla
山芹菜
角菜
赤道櫻桃


Cruciferous family
結球甘藍
Cabbage
結球白菜
Chinese cabbage
不結球白菜
Non-heading Chinese cabbage
芥藍
Chinese kale
芥菜
Mustard
油菜
Oil rape


High temperature affects the growth and development of Chinese cabbage


Heat tolerance breeding of cruciferous vegetables in Taichung DARIS
The crop includes cabbage, kale, broccoli, cauliflower and radish.
The cultivars currently bred and circulated in the market are includes Cabbage 'Taichung No.1-No.3', Chinese kale 'Taichung No.1-No.2', and radish 'Taichung No.1-No.2'.
Cabbage 'Taichung No.2' has good heat tolerant and set a record for the highest technical transfer amount for domestic vegetable cultivars.
'Taichung No.1'
'Taichung No.2'


Breeding goals
• Flat-topped ovate type, F_1
• Can cultivate during summer season in lowland Taiwan
• Single ball weight more than 600 grams
• Harvest at 30-35 days after transplanting
• No tipburn and soft-rot symptoms happened

Compositae family

Classification of Vegetables Based on Tolerance to Soil Salinity Levels

Salt Tolerance Level	Salinity Range (ppm)	Vegetable Types
High Salt Tolerance	7,700–6,400 ppm	Kale, asparagus, spinach, etc.
Moderate Salt Tolerance	6,400–2,600 ppm	Tomato, broccoli, cabbage, pepper, pepper, cauliflower, lettuce, sweet corn, potato, carrot, onion, pea, pumpkin, etc.
Low Salt Tolerance	2,600–1,900 ppm	Radish and green bean types

Classification of Vegetables Based on Adaptability to Soil pH Levels

Acid Tolerance Level	pH Range	Vegetable Types
Acid Tolerant	pH 6.8–6.0	Broccoli, cabbage, cauliflower, celery, spinach, Chinese cabbage, onion, lettuce, asparagus, etc.
Moderately Acid Tolerant	pH 6.8–5.5	Tomato, cucumber, pumpkin, turnip, turnip cabbage, pepper, radish, carrot, common bean, pea, garlic, etc.
Highly Acid Tolerant	pH 6.8–5.0	Potato, watermelon, scallion, fennel

農業部臺中區農業改良場
Taichung District Agricultural Research and Extension Station, Ministry of Agriculture

Susceptible cultivar　Disease-resistant cultivar

Resist Tomato yellow leaf cure disease -Tomato Taichung No.11

- F_1 hybrid cultivar
- Semi-determinate type
- The mature fruit is red in color, not easy to thresh.
- The fruit weighs about 48 grams, the ripening period is early.
- With *Ty1/3* and *Ty2* genes, it is resistant to tomato yellow leaf curl disease.
- Suitable for organic and open-field cultivation.

Taichung AVRDC No.1

1.F1 hybrid cultivar.
2.The fruit is a square-shaped sweet pepper that turns green to red.
3.It is a medium-sized fruit with a weight of 150-200g, thick flesh, 3-4 ventricles.
4.Resistance to tomato mosaic virus and potato Y virus; tolerance to pepper leaf vein mottle virus and pepper blight.

Taichung AVRDC No.2

1.F1 hybrid cultivar.
2.The fruit is a square-shaped sweet pepper that turns green to yellow.
3.It is a medium-sized fruit with a weight of 160-210g, thick flesh, 3-4 ventricles.
4.Resistance to chilli veinal mottle virus, potato Y virus and bacterial spot; tolerance to phytophthora capsici.

農業部臺中區農業改良場
Taichung District Agricultural Research and Extension Station, Ministry of Agriculture

Plug vegetable production short-term leafy vegetables

- Neat and healthy seedlings.
- It can control the row spacing and provide the best growth space.
- It can also ensure good ventilation and lighting.
- It can shorten the time that crops grow in a single environment and reduce the threat of pests and diseases.

Vegetable cultivation mode

Field cultivation　　Facility cultivation

Mulching
Ridging cover with plastic sheet or straw

- Covering with plastic sheets can suppress weeds, keep soil moist.
- The plastic sheet is silver on one side and black on the other.
- When covering, the silver side should be on the top and the black side on the bottom. This way the soil will not absorb too much heat. The silver will have a reflective effect, which will make small insects leave.
- Cover with straw instead of plastic in summer

Extreme climate
Utilize facility cultivation

Using facility cultivation

- The use of facility cultivation for vegetable crops can protect crop growth, improve quality, and increase yield; especially under correct management methods, it can reduce or avoid the damage caused by pests and diseases.
- Facilities can provide an isolated environment. If healthy and clean materials and seedlings can be used, and the invasion of pests and weeds can be prevented, combined with the concept of comprehensive management, attention should be paid to garden cleaning, watering, soil drying, nutrition, water, humidity and other control, then organic vegetable cultivation in facilities will be easier to implement.

Facility soil cultivation

Facility media cultivation

Simple net facility

Facility soil cultivation

Advantage

- No additional cost required
- Easy

Disadvantage

- Crop cultivation may affect to soil characteristics
- Soil-borne diseases are difficult to control (nematodes, bacterial wilt)

Facility media cultivation -trough cultivation

Facility media cultivation -Basket cultivation

Facility medium cultivation

Advantage

- Cultivation environment is easy to artificially control
- Moisture and fertilizer management is easy
- Easily avoid soil-borne pests and diseases

Disadvantage

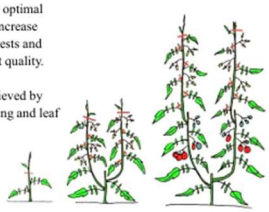
- High cost (cultivation medium, irrigation lines)

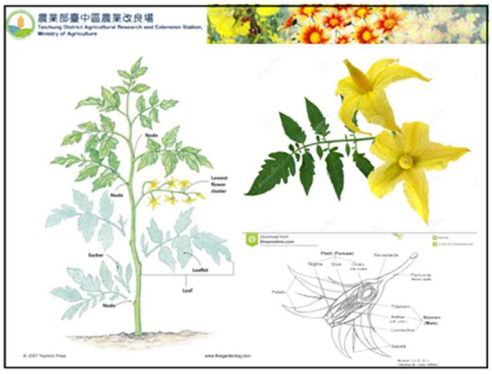
Use of tomato grafted seedlings

Tomato grafting disease-resistant eggplant root stock to control bacterial wilt

Appropriate planting density and pruning

- Timely thinning or pulling out seedlings to maintain appropriate row and plant spacing can provide optimal growth space for each plant, increase light and ventilation, reduce pests and diseases, and improve product quality.
- The same effect can be achieved by strengthening pruning, trimming and leaf removal.





Knife disinfection

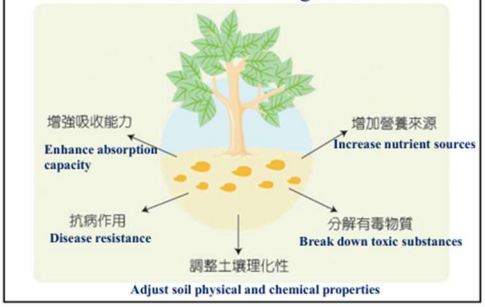
- Sodium hypochlorite (bleach) diluted 10 times
- 75% alcohol
- Most bacteria and some fungi can be killed

Fertilization

The nutrient elements needed by plants

- A large number of elements：Nitrogen(N)、Phosphorus(P)、Potassium(K)
- Minor element：Calcium(Ca)、Magnesium(Mg)、Sulfur(S)
- Trace elements：Iron(Fe), Manganese(Mn), Copper(Cu), Zinc(Zn), Molybdenum(Mo), Chlorine(Cl), Boron(B)

Promote and protect plant growth - beneficial microorganisms



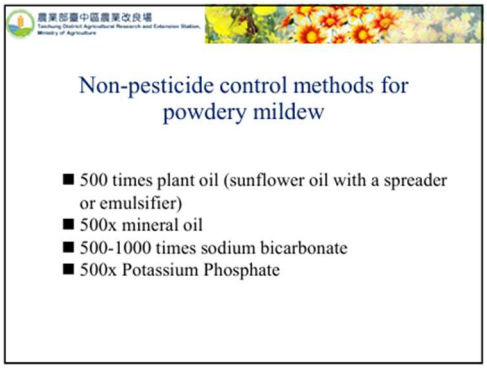
Beneficial microorganism products developed by Taichung DARIS

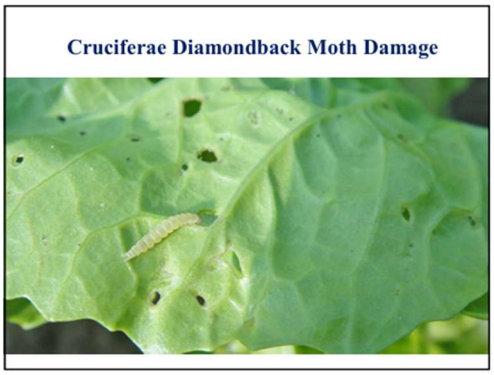
Tcba05：General purpose biofertilizer and biopesticide
Tcb45：Biofertilizer use
Tcb43：Biopesticide use, especially against melon powdery mildew


Aerobic bacteria-Trichoderma


農業部臺中區農業改良場
Bacillus promotes vegetable root growth


CK
B-Teb11
200x


農業部臺中區農業改良場
Non-pesticide control methods for powdery mildew
■ 500 times plant oil (sunflower oil with a spreader or emulsifier)
■ 500x mineral oil
■ 500-1000 times sodium bicarbonate
■ 500x Potassium Phosphate

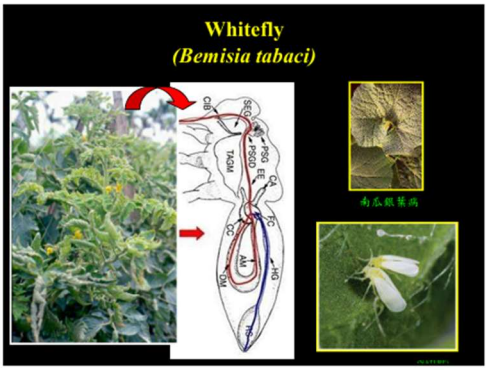

Cruciferae Diamondback Moth Damage

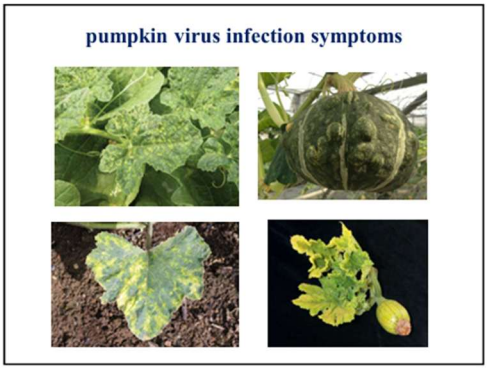

速力寶
(蘇力菌E-911)
1.Bacillus thuringiensis control Lepidoptera insects.
2.Caterpillars will have diarrhea and eventually die after eat thuringiensis.


Entomopathogenic fungus
黑殭菌

Tea seed meal is rich in saponins, which can destroy the mucus of slugs, snails, and golden apple snails. It can also be used as an organic fertilizer. It is toxic to fish and other aquatic organisms.

Neem meal contains a natural insecticide - azadirachtin. Azadirachtin can be used as an insecticide in organic agriculture.
It has a dual effect of killing insects and repelling insects. It can be used to control aphids, whiteflies, scale insects, lepidoptera larvae and spider mites. Using neem meal as a base fertilizer has a good repelling effect on soil-dwelling insects. If there are insect eggs in the soil, neem meal mixed evenly with the soil is the best organic control substance.





Smoke-blind stink bug

Cleome
(Spider Flower)

Establishing a crop rotation or intercropping system for vegetables

- Reduce the damage caused by pests and weeds and maintain the balance of soil fertility.
- Incorporate different families of crops into the crop rotation system.
- Rotation of wet and dry fields
- Cultivate a repellent plant, such as strong-smelling chives, shallots or garlic, or marigolds, whose roots secrete substances that repel nematodes.

After harvesting, completely remove the plants

Organic Integrated Pest Management (IPM)

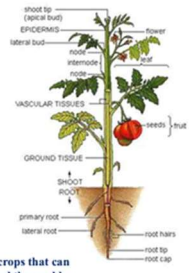
- **Crop choose**
- **Physical control**
  - Using yellow sticker paper
  - Using insect-proof netting
  - Covering the soil surface with silver plastic cloth
- **Non-pesticide control**
  - Beneficial Microorganisms
  - Citrus essential oils
- **Biological control**
  - Intermediate host control
  - Attractant or repellent crop use
  - Biological predators & parasitoids
- **Crop management**
  - Using disease-free seedling
  - Implementing a insect-host-free period
  - Crop rotation & intercropping

Principles and Applications in Post-Harvest Vegetable Processing

Yu-Heng Lin

Vegetable laboratory
Taichung District Agricultural Research and Extention station, Minstry of agriculture

- Vegetables can be divided into seven categories according to eating parts.
  1. Root vegetables
  2. Stem vegetables
  3. Leafy vegetables
  4. Floral vegetables
  5. Fruit vegetables
  6. Mushrooms
  7. Fern



There are more than 2,000 crops that can be eaten as vegetables around the world.

Why vegetable crops can help farmers make money

- A wide variety of vegetable crops
- Vegetable crops are mostly short-term crops
- People need to eat a variety of vegetables every day, and the market demand is huge.
- Vegetable crops can be produced on a small area of land

Characteristics of vegetables: tender tissue, high water content

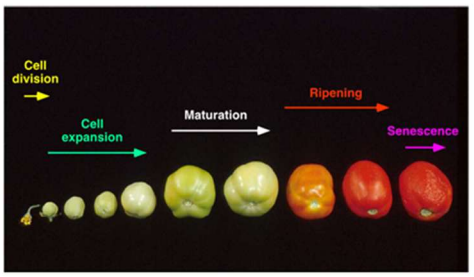
Crop	Water content (%)	Crop	Water content (%)
Cabbage	94	Cauliflower	93
Chinese cabbage	96	Broccoli	90
Chinese mustard	96	Tomato	93
Rape	93	Pepper	93
Carrot	90	Cucumber	96
Taro	72	Melon	92

Why do vegetables need to be processed and preserved after harvest?

1. Delay the aging of vegetables after harvest to maintain their quality
2. Reduce vegetable losses from harvest to consumption
3. Extend the vegetable supply time and increase the transportation distance
4. Provide consumers with a variety of choices

Quality maintenance requirements during post-harvest processing

1. Appearance
2. Texture
3. Fragrance
4. Nutritional Value
5. Safety Factors



https://rseco.org/content/chapter-11-fruit-growth-ripening-and-post-harvest-physiology.html

Physiological maturity Vs. Horticultural maturity

- **Physiological maturity: The stage of development when a plant or plant part will continue ontogeny even if detached.**

- **Horticulture maturity: The stage of development when a plant or plant part possesses the prerequisites for utilization by consumers for a particular purpose.**

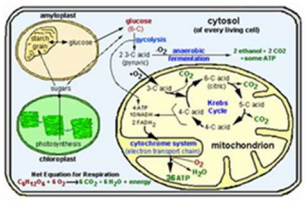
- Harvesting at the right time is crucial to the value of the product.

Physiological changes after harvest: respiration

aerobic cellular respiration

$$C_6H_{12}O_6 + 6O_2 \rightleftharpoons 6CO_2 + 6H_2O$$

photosynthesis



Factors that affect respiration rate: Types of vegetables

Table. Respiration rate of different types of vegetables

Classification	Respiration rate(mg/kg/hr)	Vegetable types
Low	5-10	Watermelon, garlic, onion, celery, potato
Middle	10-20	Melon, cabbage, heading lettuce, tomato, pumpkin
high	20-40	cauliflower, leeks, leaf lettuce
Very high	40-60	Common bean, broccoli, kale
Highest	> 60	Asparagus, mushrooms, peas, spinach, sweet corn

Factors that affect respiration rate: Temperature

If the temperature is between 0°C and 30°C without cold or heat damage, the respiration rate (chemical reaction rate) generally increases 2-3 times for every 10°C increase in temperature.

Respiration rates of different vegetables at different temperatures (mg/kg/hr)

Product Categories	0°C	4-5°C	25-27°C
Melon	5-6	9-10	62-71
Tomato	--	5-8	28-41
Common bean	20	35	193
Broccoli	19-21	32-37	278-320
Cabbage	4-6	9-12	28-49
Lettuce	6-17	13-20	73-91
Mushroom	28-44	71	264-316

Factors that affect respiration rate: Ethylene

- **Ethylene is a gaseous plant hormone that has many effects on plant growth and development. The effect of ethylene on the respiration rate of horticultural products is a common phenomenon. Most plant tissues respond to ethylene and accelerate aging.**

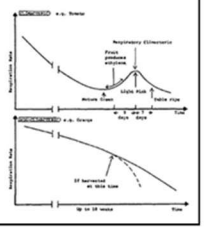
There are two types of fruit respiration pattern:

Non-climacteric fruits: Cucumber, eggplant, okra, bell pepper, watermelon

Ethylene stimulation can increase the respiratory rate, but after it is removed, the respiratory rate returns to normal

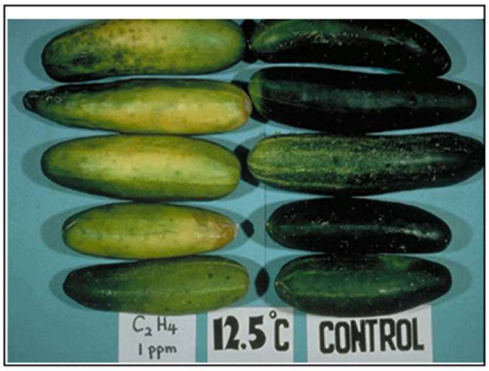
Climacteric fruits: Tomato, Mask melon

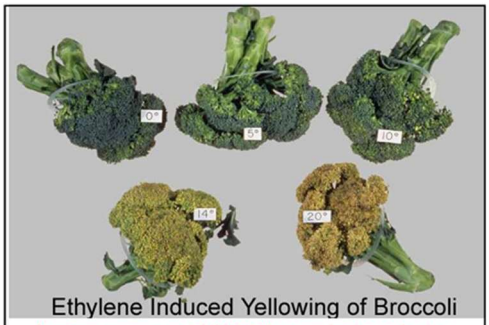
Ethylene promotes the ripening of fruits. However, once the fruits enter the ripening stage, the respiration rate will naturally increase, regardless of the concentration of ethylene in the environment.



Ethylene production rate of different vegetable types:

Classification	Ethylene production rateμl/kg.hr)	Vegetable type
Very low	< 0.1	Cauliflower, asparagus, Green leaf vegetable, potatoes
Low	0.1~1.0	Cucumber, eggplant, pumpkin, watermelon, bell pepper, chili pepper
Medium	1.0~10	Tomatoes and melons
High	10~100	Melon





Ethylene Induced Yellowing of Broccoli

Low temperature can inhibit ethylene production and aging physiology

To avoid degradation of horticultural products caused by ethylene

- Avoid Ethylene

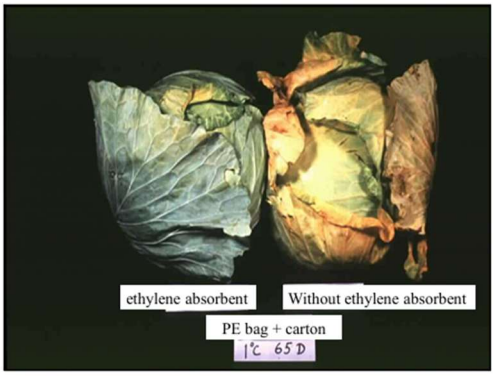
1.Store at low temperatures to prevent premature ethylene production.
2.Harvest at the right time to avoid damage during picking.
3.Avoid mixing high-ethylene production and ethylene-sensitive products.
4.Avoid using internal combustion engines in storage facilities.

- Ethylene removal

Potassium permanganate, carbon bromide, ventilation

- Inhibit ethylene action

Place ethylene inhibitor(1-MCP,STS)



1-MCP (1-methylcyclopropene)

1-MCP gas is released when water is added. MCP contacts the ethylene receptors in plant cells, producing an irreversible reaction that blocks the binding of the receptors to ethylene gas, temporarily delaying the physiological reactions of plant maturation, such as flower drop, yellowing of chlorophyll, fruit ripening, fruit drop, and leaf fall.

Inhibit ethylene action

Climacteric Fruit → SYSTEM1 → SYSTEM2 → Ethylene production

1-MCP Features

- It is **an ethylene receptor inhibitor** that has a blocking effect on both endogenous and exogenous ethylene.
- The mechanism is the same as silver thiosulfate(STS), but **without its environmental issues**.
- 1-MCP is **non-toxic**, **harmless**, and **poses no safety concerns**. It is suitable for use on flowers, fruits, vegetables, and other agricultural products, including cut flowers, potted plants, and even container plants.
- It can be used before or during storage and transportation without affecting the original operation process. It will continue to be effective after the treatment is completed.
- Currently, commercially available AnsiP is a tablet product that dissolves in water and releases into gas, making it very convenient to use.
- Because the required dosage is extremely small, MCP's preservation effect is very economical.

▼番茄 (25℃，4日)
上：1-MCP處理，未進一步轉色。
下：對照組，果實全紅。
▲番茄 (25℃，9日)
右：對照組，果實全紅軟化。
左：果實以1-MCP處理未再轉色。
◀番茄 (25℃，15日)
上：1-MCP處理，仍可轉色。
下：對照組，已無商品價值。

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▲青江菜
右：對照組，15℃下6日，外葉黃化。
左：1-MCP處理，15℃下6日。

▲青江菜
右：對照組，15℃下10日，全株黃化。
左：1-MCP處理，15℃，10日，仍維持綠色。

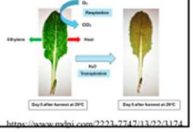
Factors that affect respiration rate: Atmosphere composition

■ Humidity
Relative humidity has no significant effect on respiration rate

■ Oxygen
Air contains 21% oxygen. Reducing the oxygen concentration to 1-10% can reduce the respiration rate of horticultural products.

■ Carbon dioxide
The carbon dioxide content in the air is 0.03%. Raising the carbon dioxide concentration to 1-20% can reduce the respiratory rate.

■ Ethylene
Stimulates increased respiratory rate



https://www.mdpi.com/2223-7747/13/22/3174

Factors belonging to the product itself

■ **Types of plants**
Different plant species exhibit different respiration rates, which are determined by genetic factors.

■ **Variety**
Different varieties of the same crop will have different respiration rates, which is also determined by genetic factors.

■ **Different parts of the plant**
Different parts or organs of a plant exhibit different respiration rates due to their different physiological functions.

■ **Stages of growth and development**
The respiration rate of plant terminal buds, young or growing organs and tissues is higher; the respiration rate of mature or dormant organs or tissues is lower.

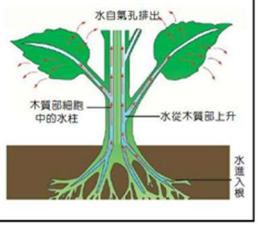
■ **Cultivation management before harvest**
The cultivation and management of crops during their growth and development in the field before harvest can also affect their respiration rate after harvest harm.
Damage to horticultural products caused by scrapes, scratches, cold damage, etc. will increase the respiration rate.

■ **Physical damage or pests and disease**
If the product is physically damaged or suffers from pests and diseases before harvest, it will also have a higher respiration rate.

Physiological changes after harvest-Transpiration

Transpiration refers to the phenomenon that water inside plants is lost from the surface of plants to the atmosphere.
Water loss from horticultural products is the result of continuous transpiration.

■ Effects of water loss on horticultural products:
(1) Reduced sellable weight
(2) Surface shriveling
(3) Wilting
(4) Texture becomes softer
(5) Loss of crispness



■ Factors affecting transpiration rate:
1. Temperature (higher temperatures lead to faster transpiration)
2. Humidity (high humidity and low transpiration)
3. Atmospheric air velocity (higher air velocity leads to faster evaporation)
4. Product factors: surface area, skin characteristics, wounds caused by post-harvest handling)

Physiological changes after harvest ~ Composition changes

■ Water loss
■ Flavor changes: Carbohydrate composition changes, citrus polysaccharides become monosaccharides.
■ Softening: Insoluble protopectin in the cell wall loses methyl groups to become pectic acid and pectin
■ Astringent substances: tannins, which combine with pectin to become insoluble when ripe
■ Color change
■ Toughness: Cellulose: Asparagus lacks water and ages
■ Changes in vitamins and minerals (vitC has a greater impact, while minerals have less impact)
■ Changes in organic acids: malic acid, citric acid, tartaric acid (maturity and ripening period decrease)
■ Changes in volatile substances and auxins (ethylene, aldehydes, esters)

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Vegetables are perishable, not durable in storage and transportation, and suffer from high transportation losses

- **Humidity**
- **Temperature**
- **Surface diffusion layer and air velocity**
- **Atmospheric pressure**

→

- **The texture becomes softer**
- **Loss of crispness**
- **Accelerated aging**
- **Product Corruption**

Harvesting and processing technology

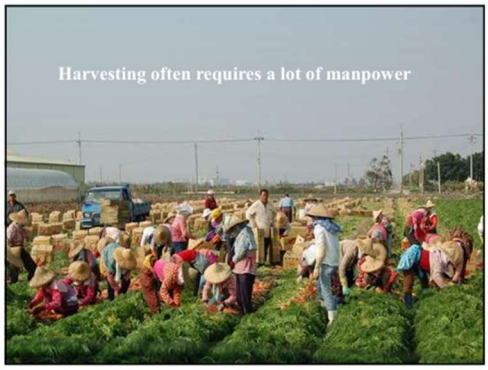
Harvesting and processing technology ~ Harvest

- Harvest maturity judgment:

1.Appearance: The common bean pods become full
2. Morphological changes: onion stems fall over
3. Color: Tomato
4. Firmness: Cabbage
5. Days after flowering: Melon
6. Other physical and chemical determinations: starch, juice content

- Harvest time:

1.Early morning harvest: leafy vegetables and sweet corn
2.It is not suitable to pick on rainy days



Self-propelled carrot harvester

Moisturizing treatment after harvest

Cover with a wet towel or cloth

Trimming and Washing

Trimming: Removing useless parts and harvesting at the same time can prevent excessive waste from reaching the packaging site.

Field Trimming

Removal of unwanted parts in the field

Washing: Remove dirt, dust, pests and diseases from the fields.

Using water for cleaning

Pre-cooling

- Field heat: The heat accumulated in the field, exposure to sunlight after harvest, and heat released by high respiration before cooling are factors in horticultural produce.
- In summer, the temperature inside the carton can reach 35-40℃
- Pre-cooling can remove field heat and accumulated respiratory heat.
- Pre-cooling refers to pre-cooling products before shipment to prevent spoilage caused by high temperatures during transportation. Without pre-cooling, large quantities of goods entering the cold storage will be overloaded and unable to cool quickly.

- Cooling method: Hydrocooling, Room cooling, Forced-air cooling, Vacuum cooling, Packaging icing.

Hydrocooling

- Precooling method using ice water as cooling medium.
- The water supply should be 400-600 liters/minute/square meter, 2℃.
- This pre-cooling method is suitable for bamboo shoots, asparagus, celery, Melon, pea pods, beans, sweet corn, etc.

Products pre-cooled with ice water are packed in cartons with plastic bags inside.

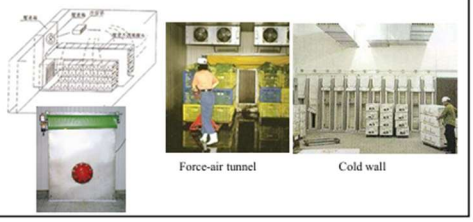
Room cooling

- Use cold air in the cold storage as the pre-cooling medium
- The operation is simple. It can be carried out with a general mechanical cold storage.
- Pre-cooling time usually takes more than 4 to 24 hours, and the wind speed should be 1-2 meters per second.
- This pre-cooling method is suitable for bulk storage products such as carrots, cabbage, Chinese cabbage, cauliflower, etc.

The Chinese cabbage after pre-cooling (left) has a better preservation effect than the control group (right)

Forced-air cooling

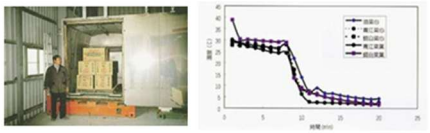
- Forced-air cooling is an improved method of Room cooling.
- According to the stacking and arrangement of products, it can be divided into force-air tunnel and cold wall.



Force-air tunnel Cold wall

Vacuum cooling

- Vacuum pre-cooling: The product is placed in a pressure-resistant chamber, and then the air is pumped out to reduce the pressure inside, rapidly cooling the product.
- Vacuum pre-cooling relies on the evaporation of water to remove
- The product loses about 1% of its weight when the temperature drops by 5℃. Usually, the product needs to lose about 1.5% to 5% of its weight during vacuum cooling.
- Newer equipment installs a sprinkler on the top of the pressure chamber for pre-humidification.



Hollow fruits are not suitable for vacuum precooling

surface shrinks

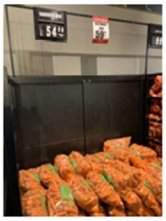
Fruit cracking

Factors affecting the cooling rate during precooling

1. Temperature difference between the cooling medium and the product:The lower the temperature of the cooling medium itself, or the greater the temperature difference between the cooling medium and the product, the shorter the time it takes to reach the low temperature required for pre-cooling, and the faster the cooling rate.
2. Heat absorption characteristics of cooling medium: Cooling media include ice water, crushed ice and cold air. Among them, ice water has the best heat absorption effect, while cold air has the worst effect.
3. Flow rate of cooling medium: The more media that comes into contact with the product per unit time, the faster the cooling rate, such as the flow rate of ice water or the circulation rate of cold air.
4. Degree of contact between product and cooling medium: Packaging methods for cooling products, such as plastic bags or cartons with insufficient openings, can reduce pre-cooling efficiency. Air flow paths can also affect the degree of contact between the product and the cooling medium.
5. Product shape and volume: Products with a large surface area, such as leafy vegetables, or smaller products, such as strawberries, cool faster.

Grading

- Grading is the classification of products into specific specifications, usually after sorting.
- Grading can be based on the weight, volume, length, diameter and other characteristics of the product.



- The clearer the grading, the more money you can make. All grades of products can be sold.

Potato quality standards

Excellent

Good

Quality standards

- Excellent: The same variety, complete shape, good color, smooth skin, no sprouts, no diseases, insect pests or other damage.
- Good: The same variety, complete shape, good color, smooth skin, no sprouts, no serious diseases, insect pests or other damage.
- Average: Secondary but commodity value

Size(Tuber weight)

- L: >200 g
- M: 150-200 g
- S:<150 g

Cabbage quality standards

Excellent

Good

Quality standards

- Excellent: The same variety, compact heads, moderate maturity, excellent color, perfect appearance
- Good: The same variety, average head density, average maturity, good color, good appearance
- Average: Secondary but commodity value

Size(Ball weight)

- L: >1.5 Kg
- M: 1.2-1.5 Kg
- S:<1.2 Kg

Tomato quality standards

Excellent

Good

Quality standards

- Excellent: The same variety, moderately mature, complete fruit shape, good color, smooth surface, no softening, perfect appearance
- Good: The same variety, average maturity, normal fruit shape, good color, smooth surface, no softening, slight appearance defects.
- Average: Secondary but commodity value

Size(weight)

- L: >250 g
- M: 200-250 g
- S:<150-200 g

Common bean quality standards

Excellent

Good

Quality standards

- Excellent: The same variety, smooth pods without protrusions, good color, tender pods, perfect appearance
- Good: The same variety, pods that are not smooth and slightly raised, good color, slightly tender pods, and average appearance
- Average: Secondary but commodity value

Size(Pod length)

- L: >20 cm
- M: 15-20 cm
- S: <15 cm

Packing

- Packaging is the process of placing products in a specific packaging container, such as a carton, wooden box or bag, in a certain arrangement.
- Field packing: Trimming and packing directly in the field. ex: Strawbery,lettuce, and celery.

Key points for field grading and packaging of cabbage for export: Clean

It is meaningful to design the packaging of distinctive Horticultural products

Conclusion

- Post-harvest processing techniques should be dependent on the characteristics of different horticultural products.
- Post-harvest processing technology can extend the storage life of horticultural products and enhance commodity value.
- Regulation market demand. Season, country, etc.