


行政院農業委員會「2010農業生技產業趨勢研討會」

分子標誌輔助育種 全球發展現況與趨勢

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Marker Assisted Selection

- **分子標誌(Molecular Marker)：**
衍生於農業產業的應用可分為1.品種鑑定；2.種子品質檢查；3.基因轉殖作物檢測；4.分子標誌輔助育種選拔。
- **分子標誌輔助育種(MAS)：**
1970年代晚期，以DNA為基礎的基因標記出現，科學家開始針對特定物種大量尋找其基因物質上的標記，並且使用這些標記去偵測與目標性狀之間的關聯性，讓傳統表現型的育種方式走向基因型的選拔，由基因層次達成培育新品種的目的。
- **MAS技術**
 - RFLP, RAPD, AFLP
 - CAPS, SCAR
 - SNP, SSR....



MAS的育種優勢

- 傳統育種方式難以針對多基因控制之性狀篩選出最佳表現之品系，尤其是抗蟲、抗病之性狀，在此情況下，MAS成為可直接偵測此群基因以確定表現強度的有力工具。
- MAS無需等待生物體表現基因，便可及早確定該品種是否具有目標性狀，這對於生長週期長的生物，更具應用優勢。
- 在傳統育種程序中，需再進行一次自交才可確認原品系是否帶有隱性基因而影響子代的性狀表現，MAS則可直接確認。
- 利用MAS可不受時空之限制，進行季節型/地域型性狀之篩選育種。
- MAS可同時篩選不同之目標性狀。

MAS發展上的限制

- MAS 需要專業的跨團隊組織合作，包括提供種原的繁殖、養殖、栽培人員以及具備實驗技術，並且能夠處理與統計實驗數據與生物資訊的人員。
- MAS 在研究設備、實驗室設計和管理需要相當的投資。

MAS對於性狀較難以從表現型篩選者，如從外觀無法判斷的疾病感染，較具有開發優勢，但對於可直接進行表現型判別的育種計畫，則多不具開發優勢。

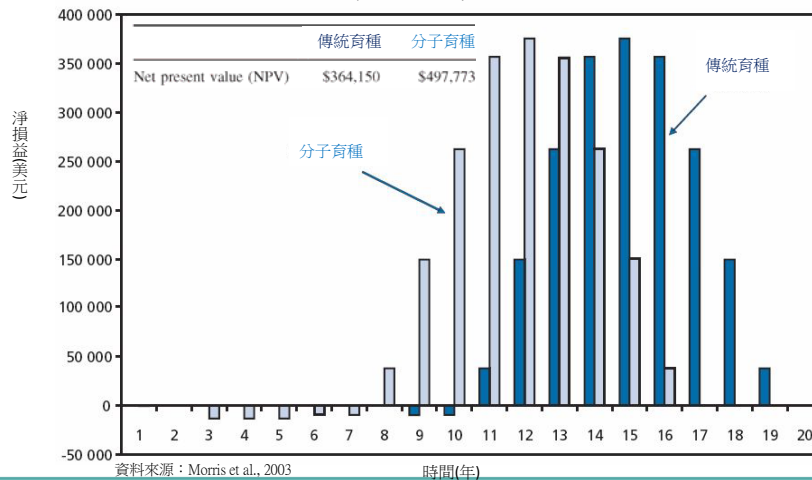
MAS的成本效益分析



- 性狀篩選的難易度
- 投入時間
- 上市速度
- 衍生的育種資訊
-

成本效益分析- 傳統育種與分子育種之產品開發淨損益圖

※以國際玉米及小麥改良中心(CIMMYT)玉米育種為例：



MAS技術應用現況

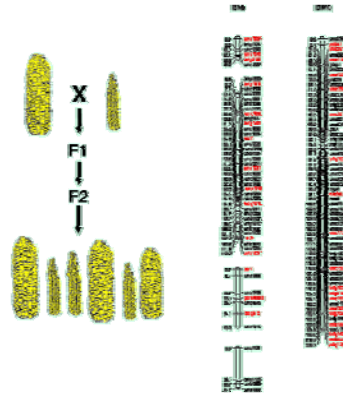
MAS在植物領域之應用- 公部門已商品化品種

Plant	Cultivar / Breeding Line	Trait	Country	Year of Release	Breeder			
Barley	Tango	Disease resistance	USA	2000	Oregon State University ¹⁸			
	SloopSA	Disease resistance	Rice	Cadet	Low-amylose	USA	2000	Texas Agricultural Experiment Station ¹⁴
	GairdnerPlus	Disease resistance		Jacinto	Low-amylose	USA	2000	Texas Agricultural Experiment Station ¹⁴
	Doria	Disease resistance		XieYou 218	Disease resistance	China	2001	China National Rice Research Institute ¹⁵
Bean	USPT-ANT-1	Disease resistance		Angke	Disease resistance	Indonesia	2002	n.k. ¹⁸
	ABCP-8	Disease resistance		Conde	Disease resistance	Indonesia	2002	n.k. ¹⁸
	ABC-Weihiing	Disease resistance		Tubigan 7	Disease resistance	Philippines	2006	Philippine Rice Research Institute ¹⁶
	USDK-CBB-15	Disease resistance		Tubigan 11	Disease resistance	Philippines	2007	Philippine Rice Research Institute ¹⁶
		Disease resistance		MAS 946-1	Disease resistance	India	2007	University of Agricultural Sciences ¹⁸
Maize	Vivek QPM 9	High-Quality Protein		Pusa 1480	Disease resistance	India	2007	Indian Agricultural Research Institute ¹⁷
		Disease resistance		RP Bio 226	Disease resistance	India	2007	Directorate of Rice Research ¹⁸
Pearl millet	HHB 67-2	Disease resistance		JTN-5303	Disease resistance	USA	2006	University of Tennessee and USDA-ARS ¹⁸
		Disease resistance		Ab2	High Yield	USA	2002	Hebrew University of Jerusalem ²⁰
		Disease resistance		Patwin	Disease resistance	USA	2006	University of California, Davis ²¹
		Disease resistance		Expresso	Disease resistance	USA	2006	University of California, Davis ²²
		Disease resistance		Lassik	Disease resistance	USA	2007	University of California, Davis ²²
		Protein content		Farnum	Disease resistance	USA	2008	Washington State University ²³

MAS在植物領域之應用-私部門應用實例-1



- DNA sequencing
- Marker development and validation
- Genetic mapping
- Marker-assisted selection
- Marker-assisted backcrossing
- Genetic fingerprinting



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MAS在植物領域之應用-私部門應用實例-2

MONSANTO



crop	trait	detailed description
Corn	Gray Leaf Spot	Historically, the areas affected by the disease have ranged throughout the Corn Belt, but Iowa, Illinois and Missouri have been the most impacted. Areas with significant Gray Leaf Spot can see yields reduced by 4 to 6 percent. Monsanto plant breeders have found novel approaches that confer resistance to the disease. They are using molecular markers to introduce these approaches into elite hybrids.
Soybean	Aphid-Resistant Soybeans	With losses as high as 50 percent in some fields from yield robbing aphids, aphid-resistant soybeans would help farmers protect and boost the yield potential on farm. Marker-assisted breeding is being used to develop aphid-resistant varieties that could be used across multiple environments.
Cotton	Root-Knot Nematode Resistance	Root-knot nematode is one of the most economically damaging cotton plant parasites with populations widespread throughout the U.S. Cotton Belt. Monsanto has been able to identify and mark cotton genes that provide a high level of resistance to control pests. Using marker-assisted breeding techniques Monsanto is introducing resistance into elite genetics to develop varieties that could potentially increase lint yield by an average of 8 to 10 percent under root-knot nematode infestations.
Vegetable	Resistance to Bacterial Wilt in Tomato	Bacterial wilt is one of the most damaging diseases to tomatoes. No pesticide control agent is currently available to contain or manage bacterial wilt. New hybrids are under development through traditional and marker-assisted breeding techniques to combine outstanding fruiting characteristics with resistance to multiple diseases.
	Downy Mildew-Resistant Cucumber	Downy mildew is a significant disease problem in cucumbers affecting yield and fruit quality globally. Growers have relied mainly on costly fungicides to control the disease. New downy mildew-resistant lines developed through conventional and marker-assisted breeding have shown the potential for a distinct yield advantage while greatly reducing the number of and costs associated with the fungicidal sprays growers currently use to control the disease.

資料來源：Monsanto 2010 pipeline

植物領域- 發展中國家分子標誌技術的研究趨勢-1

分子標誌系統	作物相關計畫累計件數			林木相關計畫累計件數		
	2006	2010	增加件數	2006	2010	增加件數
Protein marker	0	2	2	0	0	0
RFLP	61	65	4	9	14	5
RAPD	158	199	41	15	76	61
SSRs/Microsatellites	68	133	65	19	19	0
AFLP	65	94	29	3	25	22
Isozymes	2	8	4	50	52	2
Chloroplast DNA sequences	0	0	0	11	11	0
rDNA	0	0	0	4	4	0
其他未分類	135	149	14	77	61	-16
總計	489	650	161	188	262	74

資料來源：FAO-BioDeC、FAO MARKER-ASSISTED SELECTION；台灣經濟研究院生物科技產業研究中心整理

植物領域- 發展中國家分子標誌技術的研究趨勢-2

作物類別	研究計畫筆數
穀物及類穀物	203
特用作物	86
果樹類	85
豆菽類	76
根莖類	57
蔬菜類	34
飼料作物	18
香料類作物	15
其他或無特定對象之作物	76
總合	650

資料來源：FAO-BioDeC；台灣經濟研究院生物科技產業研究中心整理

MAS在畜禽領域之應用

Trait category	Direct marker*	Linkage disequilibrium marker*	Linkage Equilibrium marker*	Trait category	Direct marker*	Linkage disequilibrium marker*	Linkage Equilibrium marker*
Congenital defects	BLAD (D)			Feed intake	MC4R (P)		
	Citrulinaemia (D,B)			Disease	Prp (S)	B blood group (C)	
	DUMPS (D)				F18 (P)	K88 (P)	
	CVM (D)			Reproduction	Booroola (S)	Booroola (S)	
	Maple syrup urine (D,B)				Inverdale(S)	ESR (P)	
	Mannosidosis (D,B)				Hanna (S)	PRLR (P)	
RZR (P)	RZR (P)				RBP4 (P)		
CKIT (P)		Polled (B)	Growth and composition	MC4R (P)	CAST (P)	QTL (P)	
MC1R/MSHR (P,B,D)				IGF-2 (P)	IGF-2 (P)		
MGF (B)				Myostatin (B)		QTL (B)	
κ-Casein (D)				Callipyge (S)	Carwell (S)		
Milk quality	δ-lactoglobulin (D)			Milk yield and composition	DGAT (D)	PRL (D)	
	FMO3 (Dp)				κ-Casein (D)		QTL (D)
RZR (P)	RZR (P)		GRH (D)				
Appearance	RN/PRKAG3 (P)	RN/PRKAG3 (P)		* : (D)=dairy cattle, (B)=beef cattle, (C)=poultry, (P)=pigs, (S)=sheep			
		A-FABP/FABP4 (P)		資料來源：J. C. M. Dekkers, 2004			
		H-FABP/FABP3 (P)					
		CAST (P, B)					
	>15 PICmarq (P)†						
		THYR (B)					
	Leptin (B)						

畜禽領域- 發展中國家應用分子標誌技術之研究

Animal	Country	Technique	Animal	Country	Technique
Cattle	Argentina	Biochemical markers	Pigs	Ukraine	DNA markers (Unspecified)
	Argentina	Mitochondrial DNA		Ukraine	Cytogenetics Techniques
	Brazil	Mitochondrial DNA		Chile	Isozymes
	Burkina Faso	Blood protein markers	China	Blood protein markers	
	Burkina Faso	Microsatellites	Vietnam	Microsatellites	
	China	Blood protein markers	Horses	Ukraine	DNA markers (Unspecified)
	China	Mitochondrial DNA		Ukraine	Cytogenetics Techniques
	India	Microsatellites		Morocco	Microsatellites
	India	Isozymes	Ukraine	Biochemical markers	
	India	DNA markers (Unspecified)	Ukraine	DNA markers (Unspecified)	
	South Africa	DNA markers (Unspecified)	Goat	China	Microsatellites
	Tanzania	RAPDs		India	Microsatellites
	Ukraine	DNA markers (Unspecified)		India	Microsatellites
	Ukraine	Cytogenetics Techniques	Chicken	China	RFLPs
	Ukraine	Cytogenetics Techniques		Ukraine	Microsatellites
	Ukraine	Isozymes	Sheep	Algeria	Microsatellites
Uruguay	Microsatellites	Kenya		Blood protein markers	

資料來源：FAO-BioDeC；台灣經濟研究院生物科技產業研究中心整理

未來展望與發展建議-1

OECD預測

- **Biotech applications to 2015 for plants**

The share of all cultivated crops from varieties developed through GM, MAS, or other biotechnologies has been rising rapidly over the past ten years. This trend will continue into the future.

- **Biotech applications to 2015 for animals**

Biotechnologies such as MAS and diagnostics for pests and diseases can improve the quality and reduce the costs of livestock and poultry production, aquaculture, and honeybees.

未來展望與發展建議-2

FAO發展建議

- 針對標的物種及欲選拔性狀之特性，確認適合之育種技術並考量成本效益，將有助於最佳化應用MAS及其他創新技術。
- 可藉由推動公、私部門以及不同機構組織間之合作開發，加速MAS技術的開發與提升MAS應用效率。
- 育種計畫為一複雜且需多方考量之過程，MAS可搭配或整合其他育種技術，提升整體育種效率。

簡報結束，敬請指正！

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