



Application of Multispectral Imaging (MSI) Technology to Seed Physical Purity Analysis

Focus crops: Oil seed rape and Onion

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MSI is widely being used in Agriculture and Horticulture sectors for various applications



The image shows the MSI system components and a diagram of its operation. On the left, a photograph shows a curved array of multi-colored LEDs. Below it, a schematic diagram labels the 'Camera', 'Emission filter wheel', 'Integrating sphere', 'LEDs', and 'Sample'. In the center is a black, dome-shaped sensor unit. On the right, a diagram illustrates the light path: a 'Light source' (sun) emits an 'Incident beam' (red arrow) onto a 'Material sample', which reflects a 'Reflected beam' (purple arrow) to a 'Sensor'. Below this, a spectral diagram shows a color spectrum from 200 nm to 1000 nm, with 'ultraviolet (UV)' from 200-400 nm and 'near-infrared (NIR)' from 700-1000 nm. A stack of colored images is shown below the spectrum, labeled 'N images obtained at N specific wavelengths'.

- ✓ 19 high power LED sources with a range from 365 nm to 970 nm
- ✓ One optional external light source
- ✓ Image size: 2992*4096 pixels
- ✓ Resolution ~30 $\mu\text{m}/\text{pixel}$
- ✓ Dynamic range: optimized according to the application using auto light setup
- ✓ Very homogeneous and diffuse illumination
- ✓ Strobed LED light source
- ✓ 10 sec per sample including handling

- ❖ Wide spectral bands range is applicable to image accurately the vegetable and agriculture crop seeds
- ❖ LED light source provide high illumination to image seed classes accurately
- ❖ Clear images (blobs) generated and analyzed for each seed unit

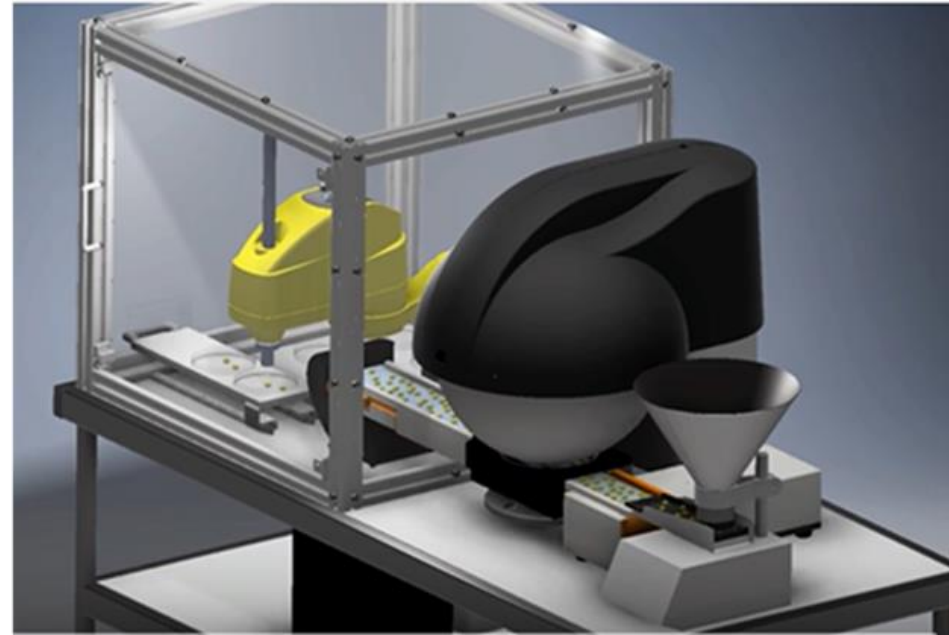
Why application of MSI technology is relevant to seed purity analysis?

Current



- Manual
- Subjective
- Long lead times in peak seasons
- Impact on reliability of quality data
- Increased likelihood to get the complaints
- Ergonomic issue: Eye strains, shoulder & headache

Future



- Digital technology
- Standardized
- Potential reliable and reproducible data
- Fulfill the grower's quality demand
- Complaints reduction
- Harmonization of testing Method
- Record and storage of images for track and trace purpose



Discovery and Development Phase



We demonstrated that MSI technology has capability to image Pure seeds with 99.9% accuracy in *Brassica napus*

Proof of concept: analysis of pure seeds and impurities in isolated fractions

Classes	Referenced (#)	Predicted (#)	Pure seeds	Inert matter	Other seeds	Sand and soil	Insects
Pure seeds	19943	19931	99.9%				
Inert matter	2455	2445		99.6%			
Other seeds	967	878			90.08%		
Sand and Soil	181	165				91.2%	
Insects	44	40					90.9%



Success

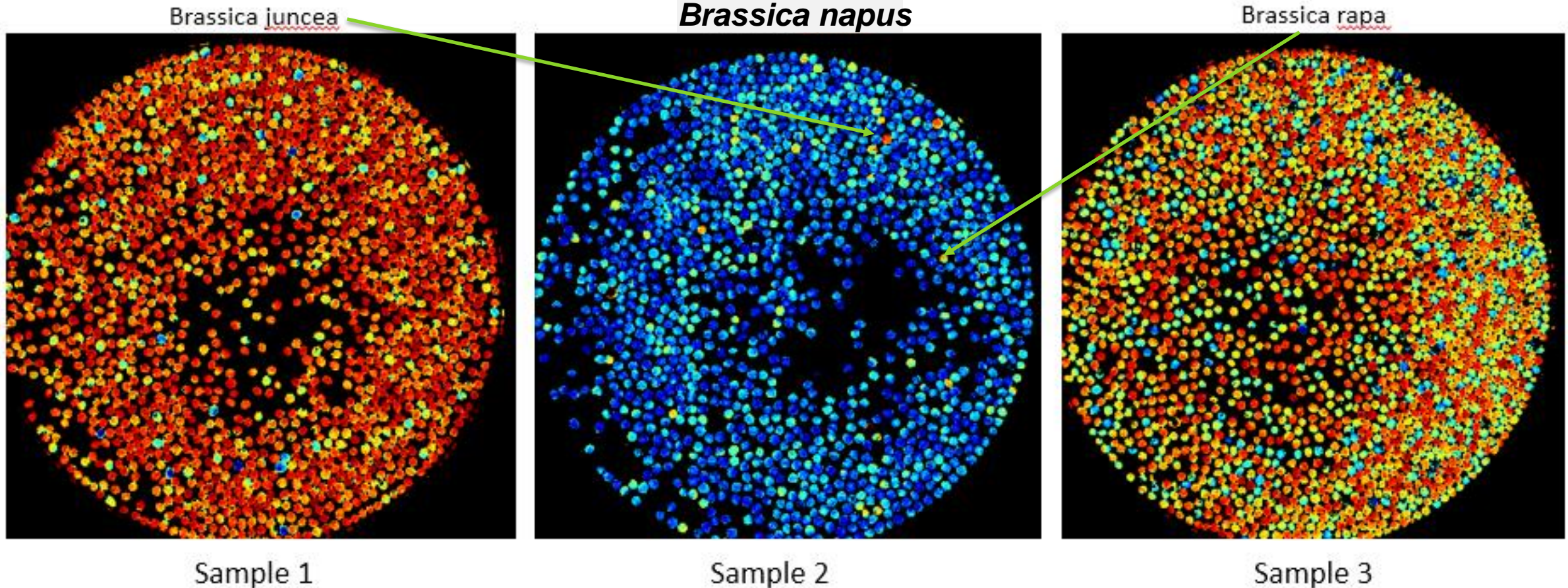
❖ Proof of concept on oil seed rape completed in 2021 confirmed accurate imaging of pure seeds and inert matter fractions

Challenges

- ❖ Require large number of foreign seeds to develop the models accurately
- ❖ At least 200 insects per type required to improve the imaging accuracy



MSI technology discriminated species mixture accurately in *Brassica napus*



- ❖ Possible to generate results by count, optical weight and percentage
- ❖ Manually very challenging task for the analysts to identify species mixture



We demonstrated that MSI technology has capability to image Pure seeds with 99.9% accuracy in *Allium cepa*

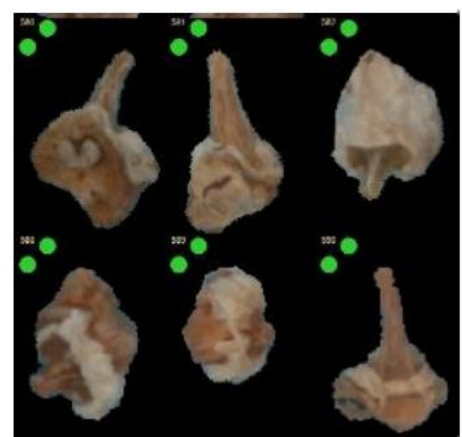
Proof of concept: analysis of pure seeds and impurities in isolated fractions

Classes	Referenced (#)	Predicted (#)	Pure seeds	Inert matter	Other seeds	Damaged seeds	Attached PI parts
Pure seeds	15811	15792	99.9%				
Inert matter	634	540		85.2%			
Other seeds	10044	10029			99.9%		
Damaged seeds	297	264				92.4%	
Attached pl parts	819	801					97.8%

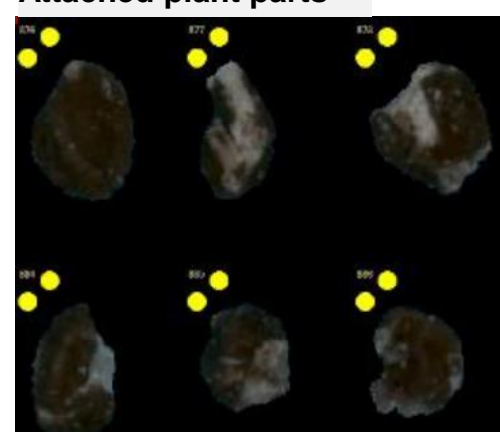
Pure seeds



Inert matter



Attached plant parts



MSI technology identified other seeds with >99% accuracy



Proof of concept: analysis of other seeds in isolated fractions

Other seeds	Referenced #	Predicted #	Amaranthus Spp	Lolium Spp	Picris Spp	Polygonum convolvulus	Polygonum persicaria	Galium aparine	Solanum Spp	Stellaria Spp
Amaranthus Spp	1248	1240	99.4%							
Lolium Spp	936	927		99.0%						
Picris Spp	1851	1850			99.9%					
Polygonum convolvulus	1006	1001				99.5%				
Polygonum persicaria	1394	1377					98.8%			
Galium aparine	1080	1071						99.2%		
Solanum Spp	1621	1615							99.6%	
Stellaria Spp	908	901								99.2%



- ❖ Proof of concept confirmed the accurate imaging of diversity of other seeds
- ❖ Accomplished an overall target of 99% imaging accuracy



Proof of Concept Phase



Proficiency Test- Experimental Design

Item	Method followed
Goal	Compare the performance of MSI* vs ISTA accr. Labs
Crops	Onion and Oil seed rape (OSR)
# Labs participated	5 (2x internal, 2x official & MSI system)
Tests	Physical Purity and Other seed determination
Design	<ul style="list-style-type: none">❖ 4 samples/ crop❖ Sample size Onion= 80 gr./sample❖ Sample size OSR =100 gr./sample
Sample Preparation	Trained sampler from internal ISTA accredited lab PEY, France
Result comparison	Human analyst vs digital analyst (MSI Technology)

****Performance of MSI= Imaging accuracy and optical weight of all fractions***



MSI technology has scored A rating for Pure seeds in PT test including internal and external labs for *Allium cepa*

- ❖ Optical weight of pure seeds, Other seeds and Inert matter fraction is very well in line with other 4 labs used physical balance for weight determination

	Pure seeds				Other seeds				Inert matter			
Lot #	Lot1	Lot2	Lot3	Lot4	Lot1	Lot2	Lot3	Lot4	Lot1	Lot2	Lot3	Lot4
MSI%	99.83	99.97	99.88	99.93	0.12	0.02	0.09	0.05	0.05	0.01	0.03	0.02
Overall Mean%	99.89	99.99	99.84	99.90	0.06	0.01	0.11	0.10	0.05	0.00	0.05	0.00

Sum of abs Z-score for Pure seeds **2.85**

In-round rating for MSI is **A**

Overall Mean%= MSI and 4 laboratories analyst % In-round rating is based on ISTA rules for PT & update the Z score ratings



MSI technology has scored A rating for Pure seeds in PT test including internal and external labs for *Brassica napus*

- ❖ Optical weight of pure seeds, other seeds and inert matter fraction is very well in line with other 4 labs used physical balance for weight determination

	Pure seeds				Other seeds				Inert matter			
Lot #	Lot1	Lot2	Lot3	Lot4	Lot1	Lot2	Lot3	Lot4	Lot1	Lot2	Lot3	Lot4
MSI%	99.83	99.57	99.95	99.67	0.06	0.41	0.03	0.29	0.11	0.02	0.02	0.04
Overall Mean%	99.83	99.51	99.90	99.56	0.04	0.46	0.05	0.31	0.13	0.03	0.05	0.13
Sum of abs Z-score for pure seeds 1.52												
In-round rating for MSI A												

MSI has accomplished A rating for other seeds, however further development is required for identifying other species - *Allium cepa*



Species level rating

ONION MSI Results								
Species	# of Seeds added	Retrieval rate %	Factor	# of Seeds found	# of seeds added X Factor	# of seeds found X Factor	Correct species?	Other remarks
<i>Allium schoenoprasum</i>	5	20%	1	1	5	1		4 unknown
<i>Amaranthus spp</i>	10	82%	1	9	10	9		1 unknown
<i>Anethum graveolens</i>	2	80%	1	2	2	2		
<i>Avena fatua</i>	2	70%	1	0	2	0		unknown
<i>Daucus carota</i>	5	97%	3	5	15	15		unknown
<i>Galium aparine</i>	6	90%	3	6	18	18		
<i>Picris spp</i>	5	96%	3	4	15	12		1 unknown
<i>Polygonum convolvulus</i>	7	100%	3	7	21	21		1 unknown
<i>Polygonum persicaria</i>	12	100%	3	12	36	36		unknown
<i>Rumex spp</i>	3	85%	2	2	6	4		1 unknown
<i>Solanum spp</i>	8	95%	3	7	24	21		1 unknown
SUM	65			55	154	139		
Percentage						90		
In-round rating						A		



- ❖ MSI requires strong modules development by adding vast majority of critical other seeds species
- ❖ *Allium schoenoprasum*, *Avena fetua* and *Dacus carota* are added as surprise species and MSI untrained
- ❖ *Avena fatua* content was one double seed which was outside the size scope of the MSI model. It will generally be recognized with correct scope.
- ❖ Build an unknown bucket is required to determine the other seeds manually

MSI has accomplished C rating for other seeds, however further development is required for identifying other species- *Brassica napus*

Species level rating

OSR MSI Results								
Species	# of Seeds added	Retrieval rate %	Factor	# of Seeds found	# of seeds added X Factor	# of seeds found X Factor	Correct species?	Other remarks
<i>Amaranthus spp</i>	15	87%	2	7	30	14		unknown
<i>Galium aparine</i>	13	87%	2	11	26	22		unknown
<i>Lolium spp</i>	5	100%	3	5	15	15		
<i>Picris spp</i>	5	92%	3	4	15	12		1 unknown
<i>Pisum sativum</i>	2	100%	3	2	6	6		
<i>Polygonum convolvulus</i>	3	100%	3	3	9	9		
<i>Polygonum persicaria</i>	4	100%	3	4	12	12		
<i>Rumex spp</i>	4	84%	1	2	4	2		2 unknown
<i>Sinapis alba</i>	12	88%	2	9	24	18		3 unknown
<i>Sinapis arvensis</i>	3	40%	1	2	3	2		1 unknown
<i>Stellaria spp</i>	8	70%	1	0	8	0		unknown
<i>Triticum aestivum</i>	4	100%	3	4	12	12		
SUM	78			53	164	124		
Percentage						76		
In-round rating						C		

- ❖ MSI requires strong modules development by adding vast majority of critical other seeds species
- ❖ *Sinapis alba* and *Stellaria spp* are added as surprise species and MSI untrained
- ❖ Building an unknown bucket is required to determine the other seeds manually



Summary

Pure seed

Inert matter

Other seeds

OSD

Discovery & Development

Onion

OSR



Proficiency Test

Onion

OSR



>99%

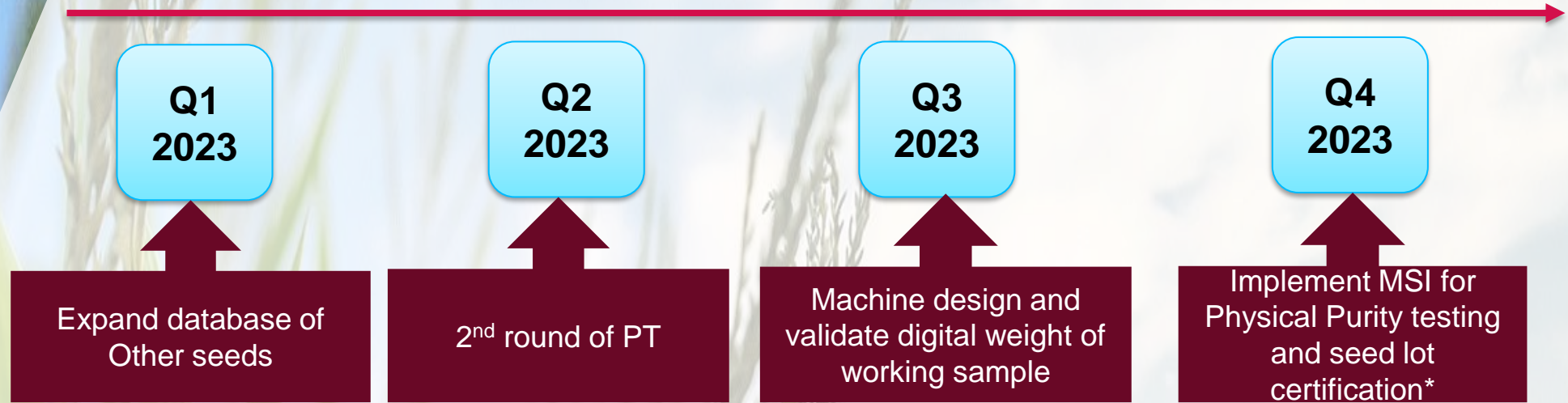


>90%



76%

MSI technology implementation timeline for seed lot certification



**After obtaining support from ISTA*

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Thank you!

