Seed Maturity and Drying Methods at Harvest are Critical to Seed Desiccation Tolerance and Quality: Impact on Food Security

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Impact of Climate Change on Food Security

- The increase in temperature and the decrease in rainfall (drought), resulting from climate change, would adversely affect quantity and quality (seed germination and vigor) of the produced seeds worldwide.

- Most of Jordan's land is desert (with less than 200 mm annual precipitation).

- In Jordan, rainfed crops are grown in winter under rainfed conditions (in area with annual rainfall ranging from 250-500 mm).

- With the climate change, Jordan is experiencing more frequent drought and severe extended late drought stress, resulting in prematurely terminating plant life cycle and producing immature seeds.

- Late drought stress has been reported to reduce barley grain production by 50% (Samarah, 2005).

Samarah N. 2005. *Agron. Sustain. Dev*. 25, 145–149

- Drought stress not only reduces seed quantity, but also results in production of high amount of immature seeds with low quality.

- The supply of high quality seeds to farmers is a key factor to maintain crop production and food security.

Field of Common Vetch Grown in Jordan

Field of Common Vetch Grown in Jordan at Harvest

Impact of Pod Maturity at Harvest on Seed Quality

- Stage of pod maturity at harvest date may influence seed yield, dormancy, and germination (seed desiccation tolerance).

- Seed dormancy is defined as the seeds are unable to germinate under optimum conditions.

- Seed germination is defined as the ability of seeds to produce normal seedlings under optimum conditions.

- Seed desiccation tolerance is defined as the ability of seeds to survive drying to a low moisture content and germinate upon rehydration.

- Delay of seed harvest of a crop increases seed losses due to shattering (seed drop from pods); however, early harvest reduces seed germination and increases seed dormancy.

- Identifying the stage of maturity at which seeds can be harvested without lowering their germination is a beneficial practice for farmers to maximize seed yield and quality.

- During the last ten years, several experiments have been conducted to study seed germination capability and desiccation tolerance during seed development and maturation.

- In this presentation, data on common vetch, soybean, and wheat will be shown.

Pod Development Stage at Harvest

Pod Developmental Stage	Description	
Beginning of Pod Fill **(BS)**	Pods were green Seeds were at the beginning of seed fill	
Mid-Full Seeds **(MS)**	Pods were green Seeds filled half of pod cavity	
Full-Size Pod **(FS)**	Pods were green Seeds filled the whole pod cavity	
Greenish Yellow Pod **(GY)**	Pods were greenish yellow. Seeds filled the whole pod cavity	
Yellow Pod **(Y)**	Pods were yellow. Seeds filled the whole pod cavity	
Brown Pod **(B)**	Pods were brown. Seeds began to dry down in the pod cavity	

Sequence of Seed Development in Soybean Pods

Beginning of Pod Fill (BS)

Mid-Full Seeds (MS)

Full-Size Pod (FS)

Iowa State University Extension Publication

Sequence of Color and Size Changes of the Soybean Pod and Seed

Full-Size Pod (FS)

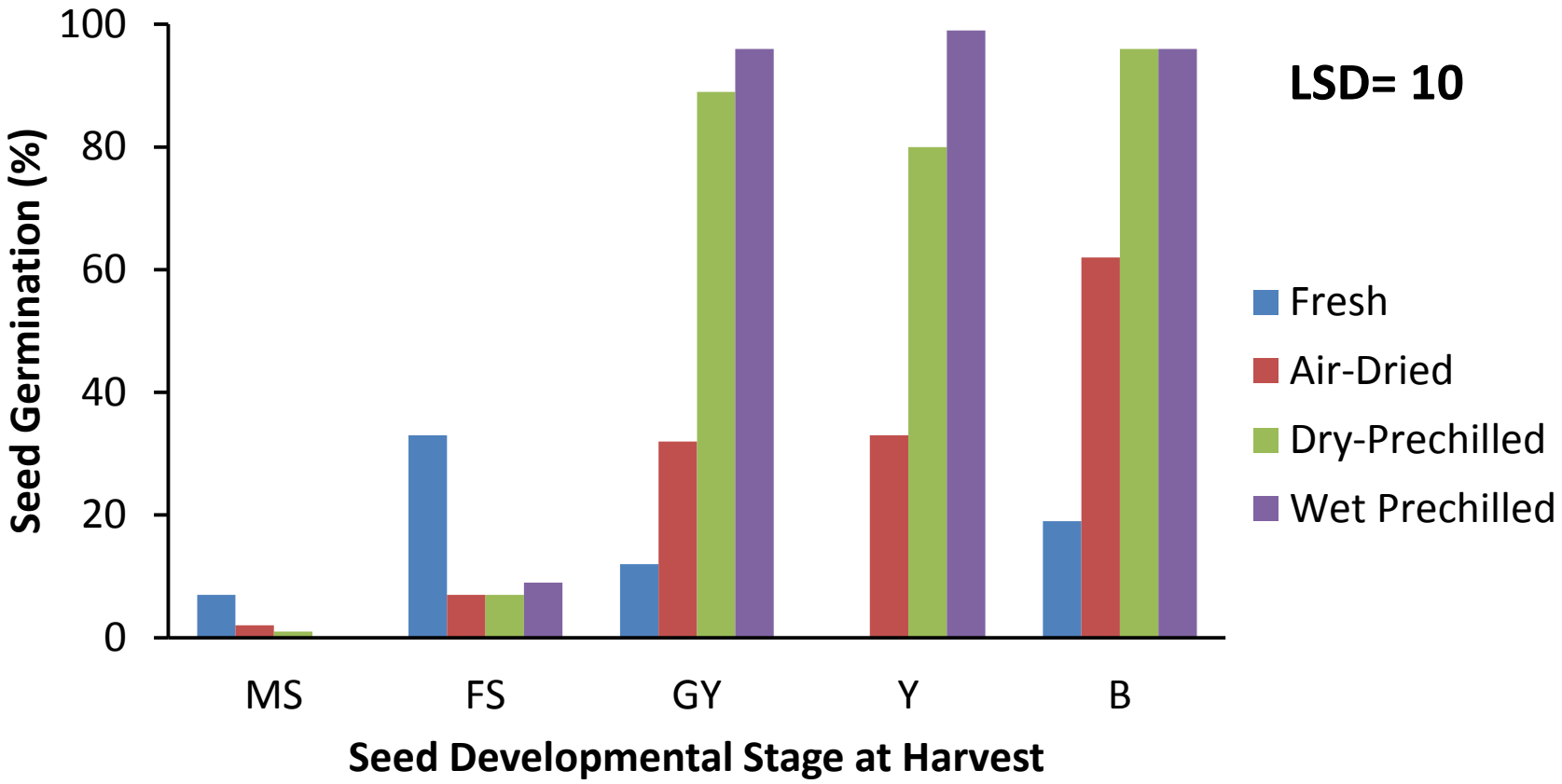
Greenish Yellow Pod (GY)

Yellow Pod (Y)

Brown Pod (B)

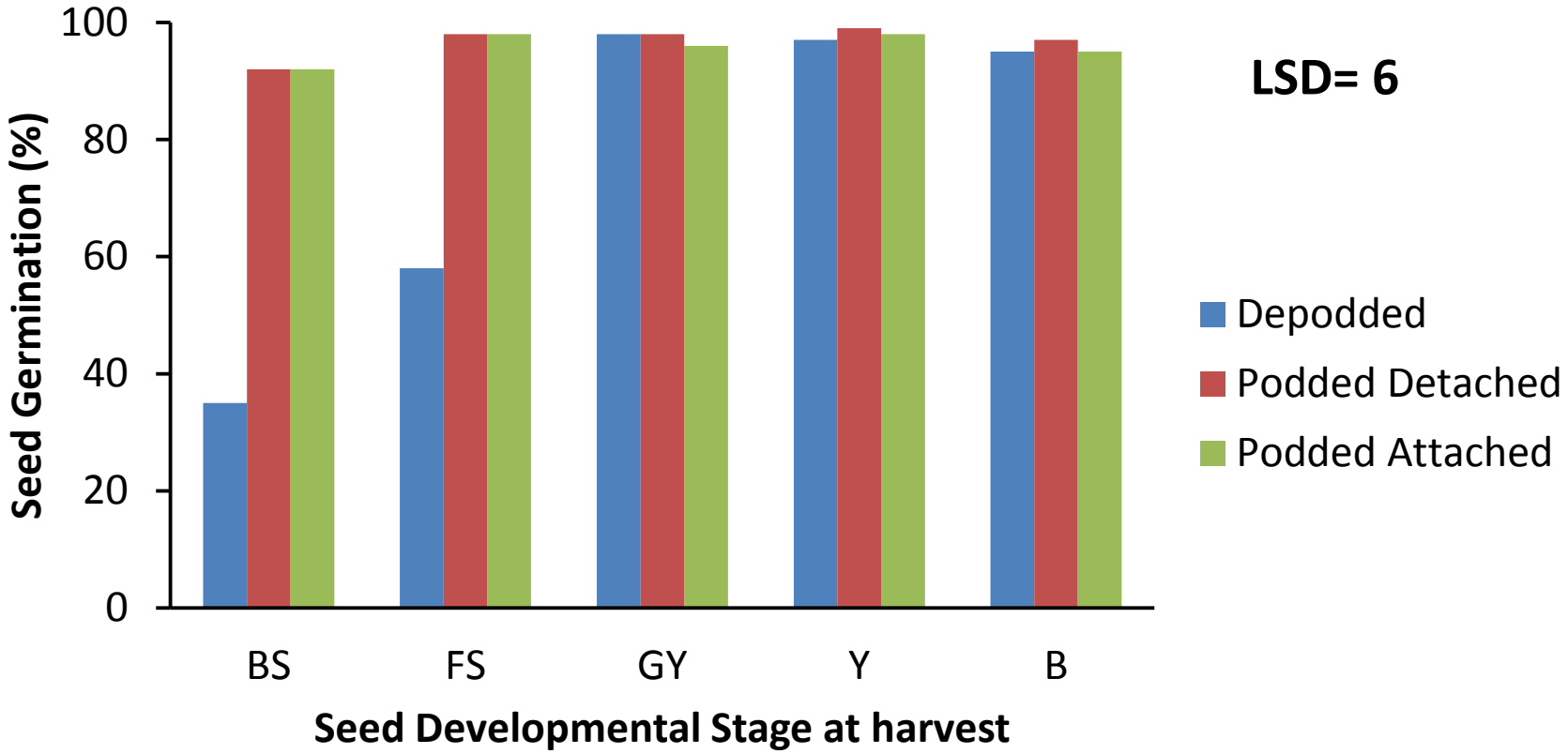
Iowa State University Extension Publication

Effect of Air-Drying and Prechilling on Seed Germination of Common Vetch



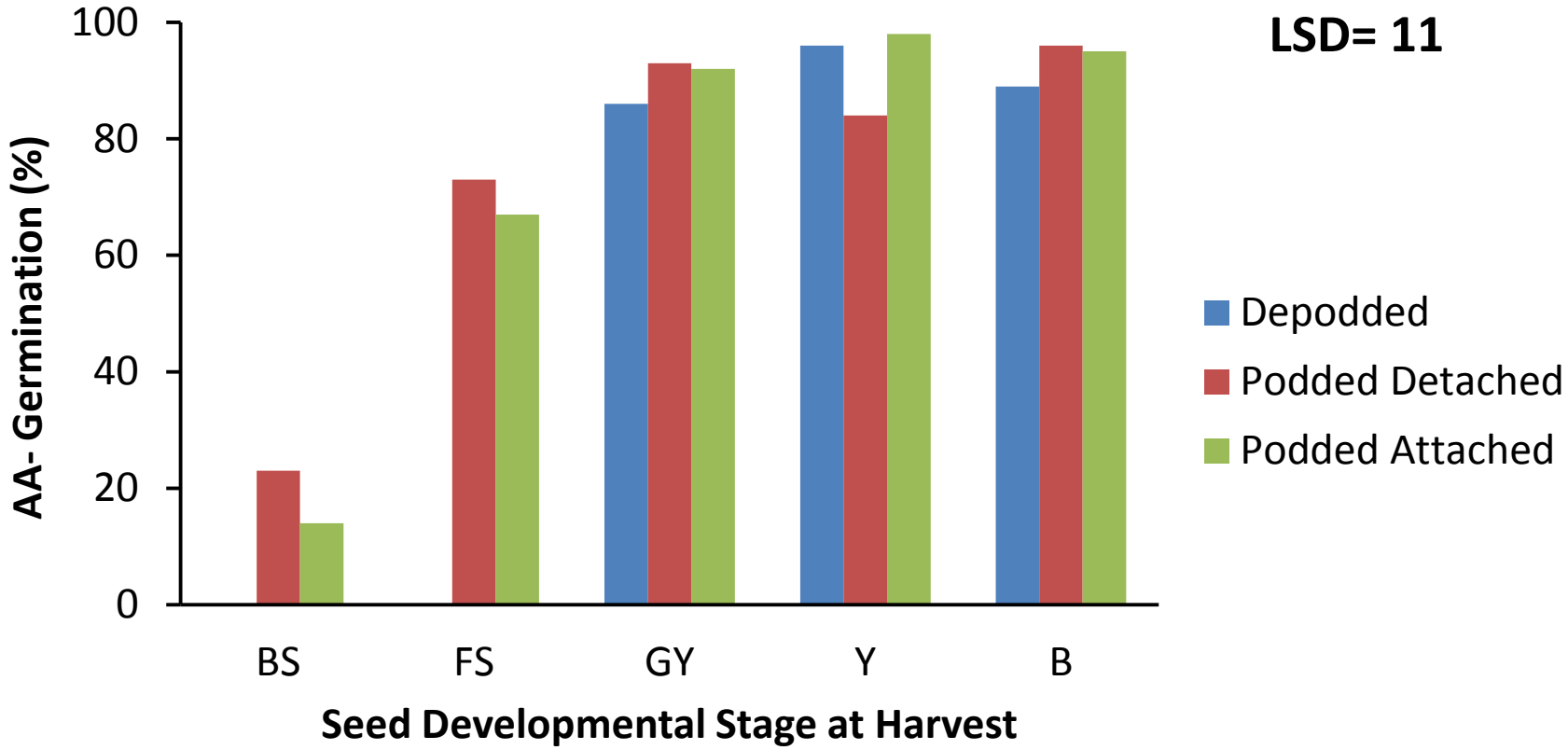
Samarah et al. (2004). *Seed Sci. & Technol.,* 32, 11-19

Effect of Drying Seeds in Pods on Seed Germination of Common Vetch



Samarah (2005). *Seed Sci. & Technol.,* 33, 733-740

Effect of Drying Seeds in Pods on Seed Vigor (as Estimated by Accelerated Aging Test [AA]) of Common Vetch



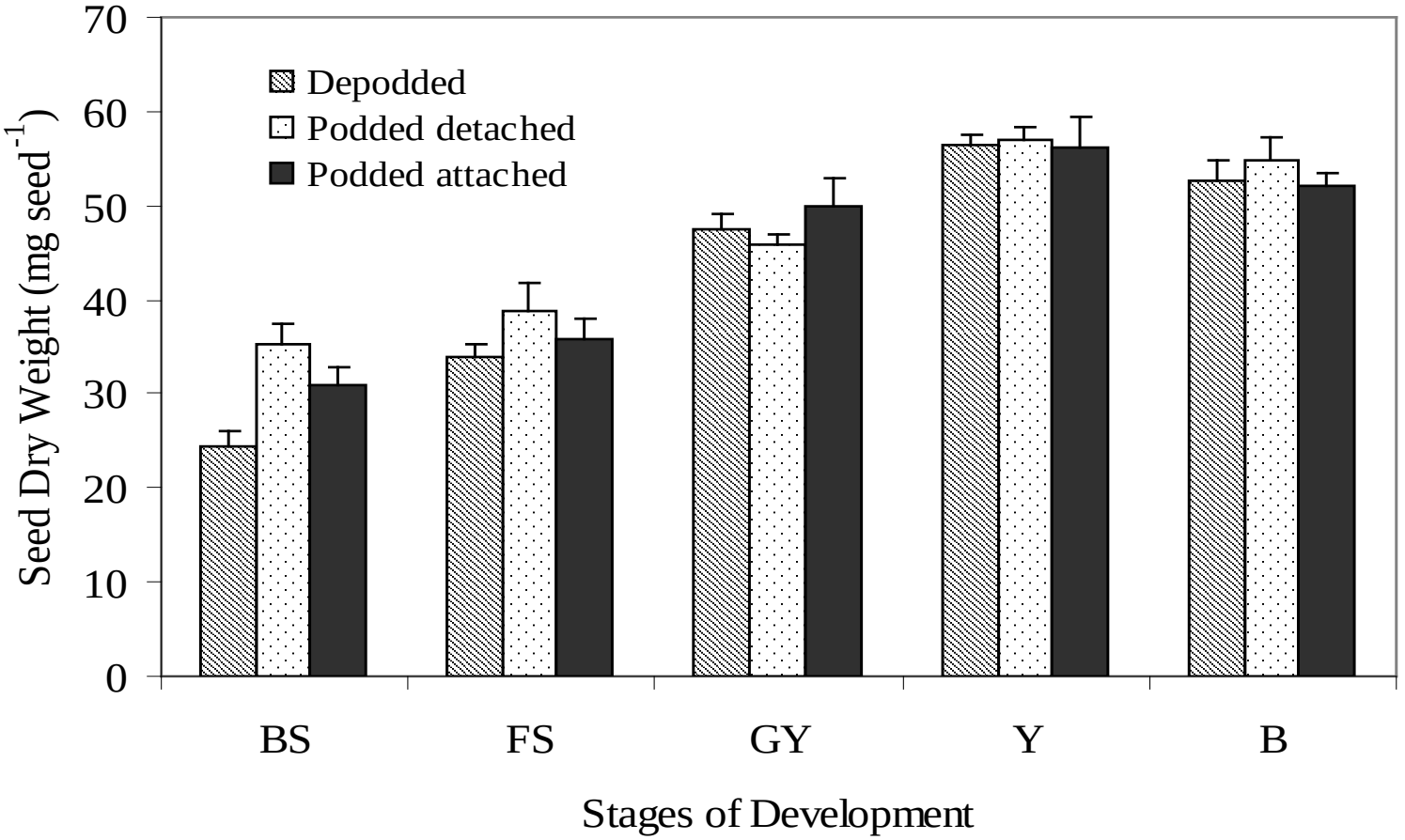
Samarah (2006). *New Zealand Journal of Agricultural Research*, 49, 331-339

How Did Drying in Intact Pod Improve Seed Germination?

- Either by:
  - Additional gain in dry weight of the podded dry seeds

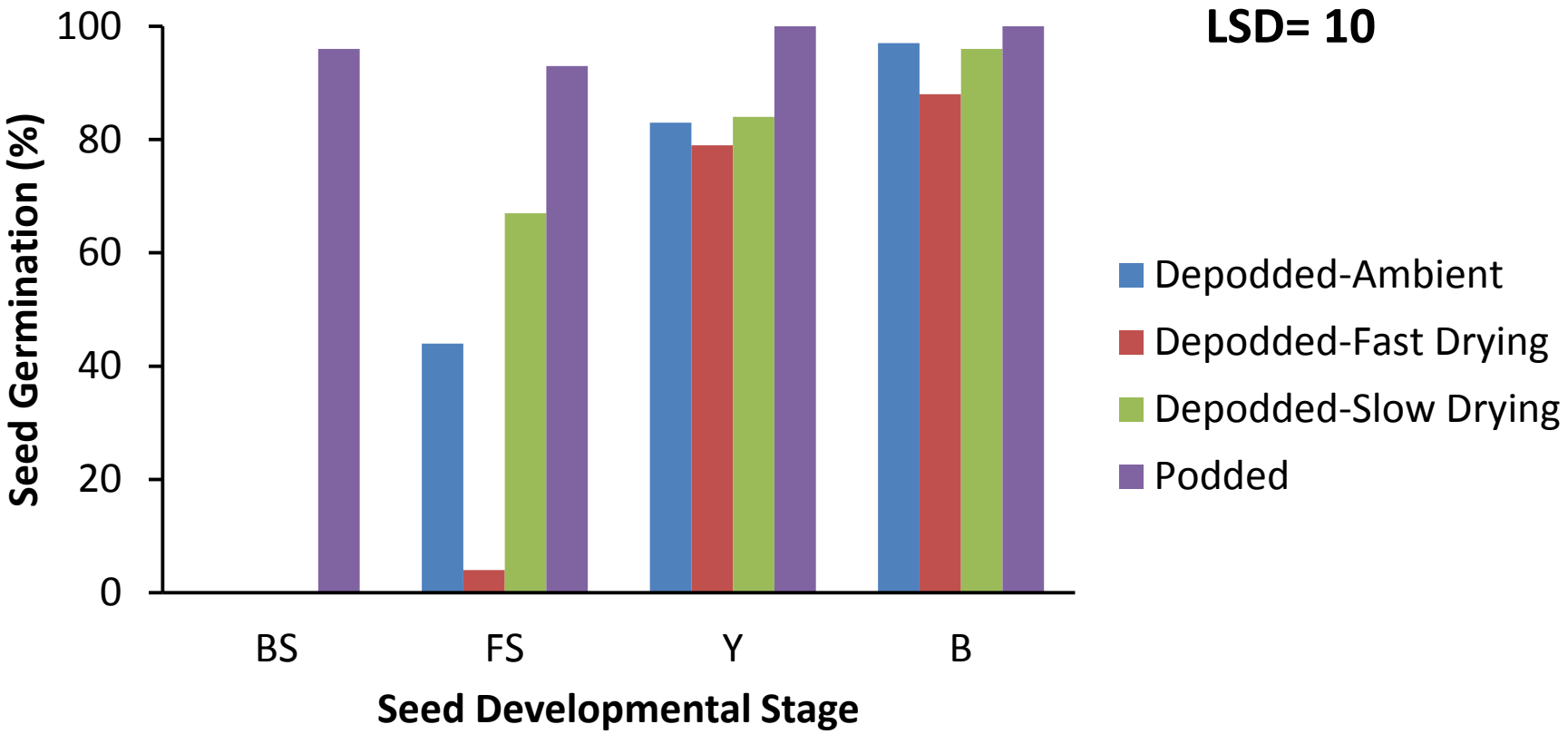
    or
  - Slower rate of seed moisture loss

Seed Dry Weight



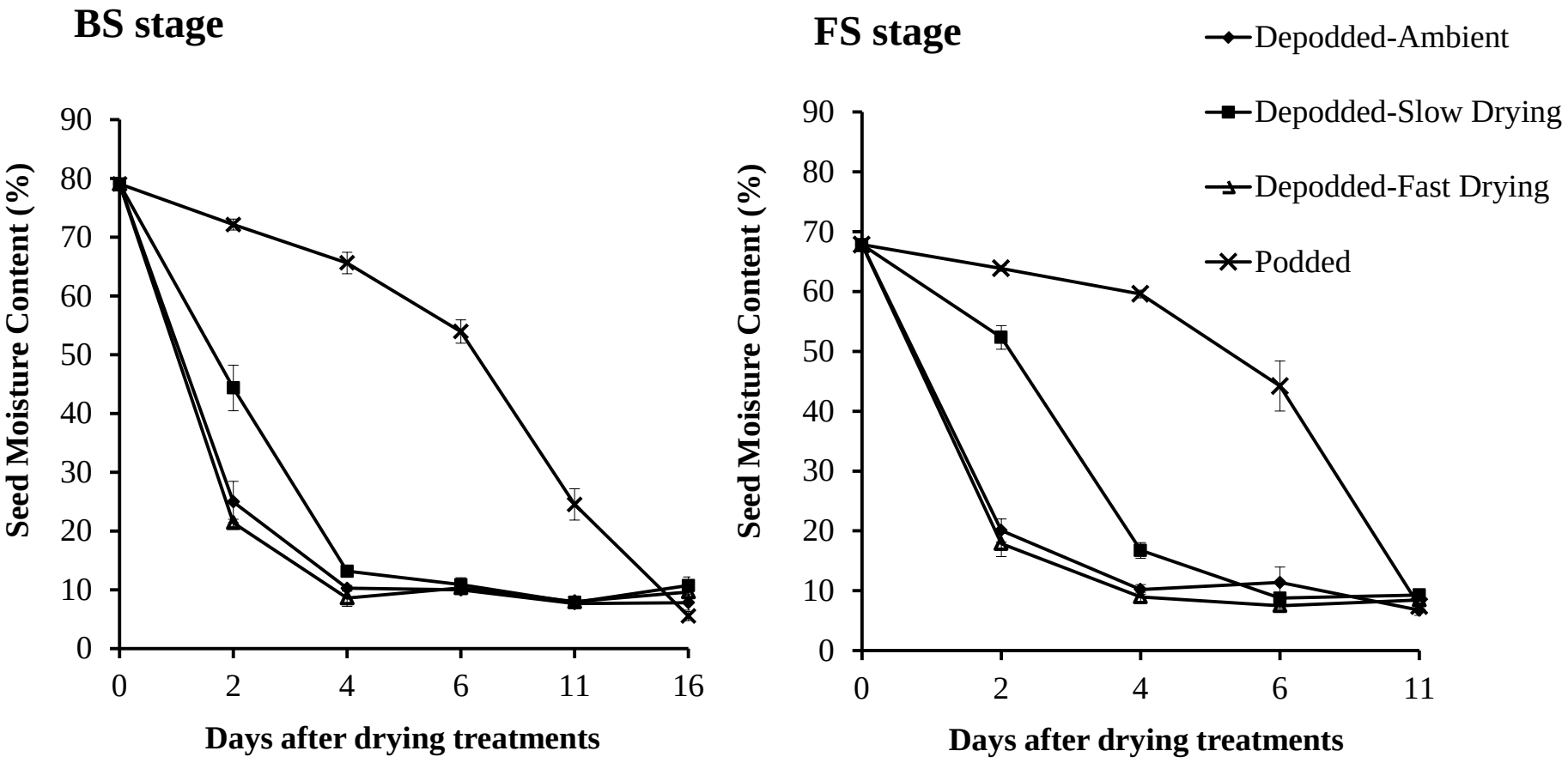
Samarah (2006). *New Zealand Journal of Agricultural Research*, 49, 331-339

Effect of Drying Rate on Seed Germination of Common Vetch



Samarah et al. (2009). *Seed Sci. & Technol.,* 37, 413-422

Seed Moisture Loss During Seed Drying



Samarah et al. (2009). *Seed Sci. & Technol.,* 37, 413-422

Developing an Index to Quantify Seed Moisture Loss Rate in Relationship with Seed Germination (Desiccation Tolerance)

$$SMLR = \sum_{i=1}^{n} \frac{(SMC_i - SMC_{i+1})}{day_{i+1}}$$

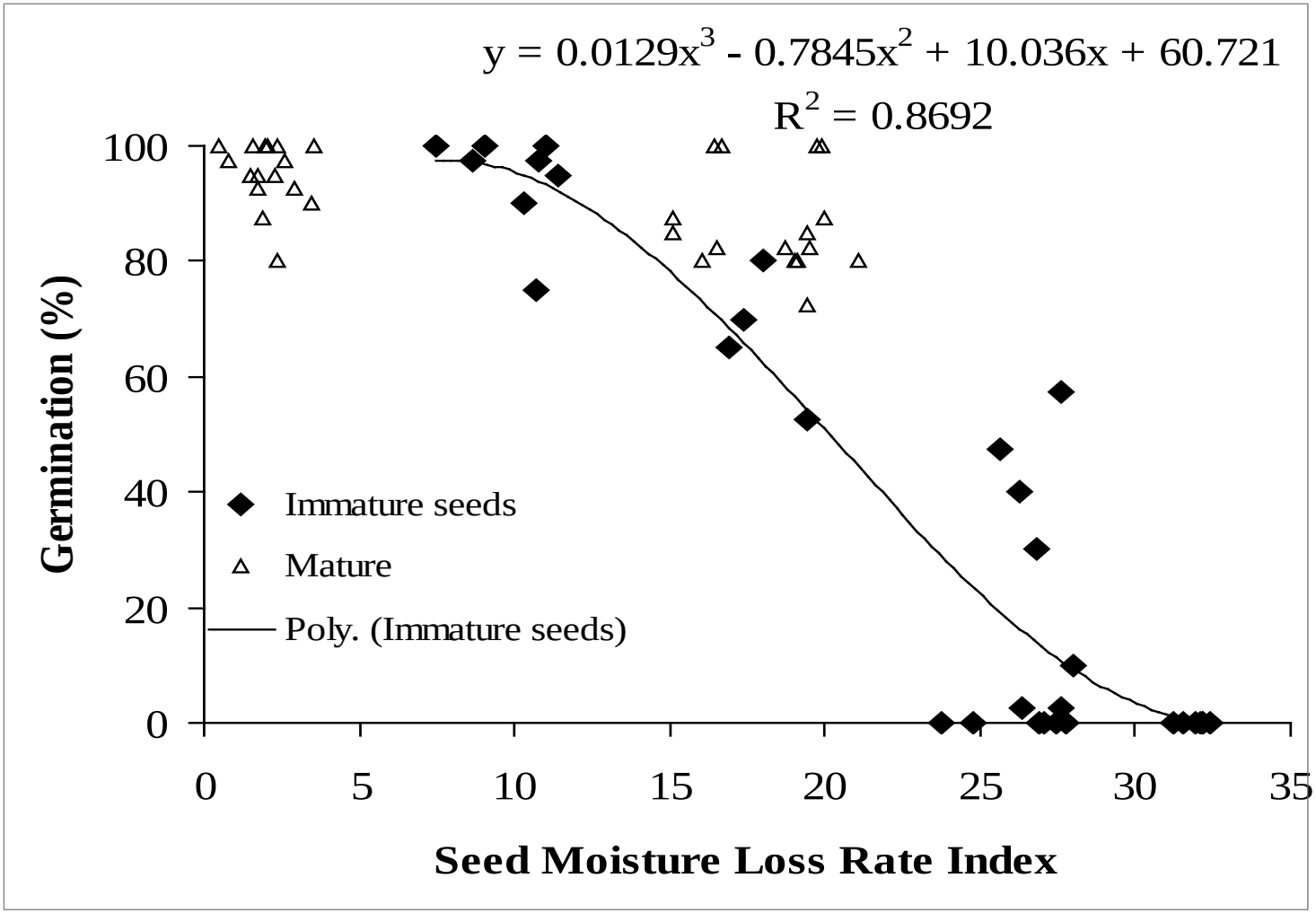
SMLR: Seed Moisture Loss Rate Index.

n: number of samples that were taken to measure seed moisture content from the harvest time to the end of the drying treatment.

SMC_i: Seed moisture content at the sample number i.

Day_i: number of days after imposing drying treatment at the sample number i.

Relationship of SMLR Index and Seed Desiccation Tolerance of Common Vetch



Immature seeds: harvested at BS and FS stages; **Mature seeds:** harvested at Y and B stages

Samarah et al. (2009). *Seed Sci. & Technol.,* 37, 413-422

Results on Other Important Crops

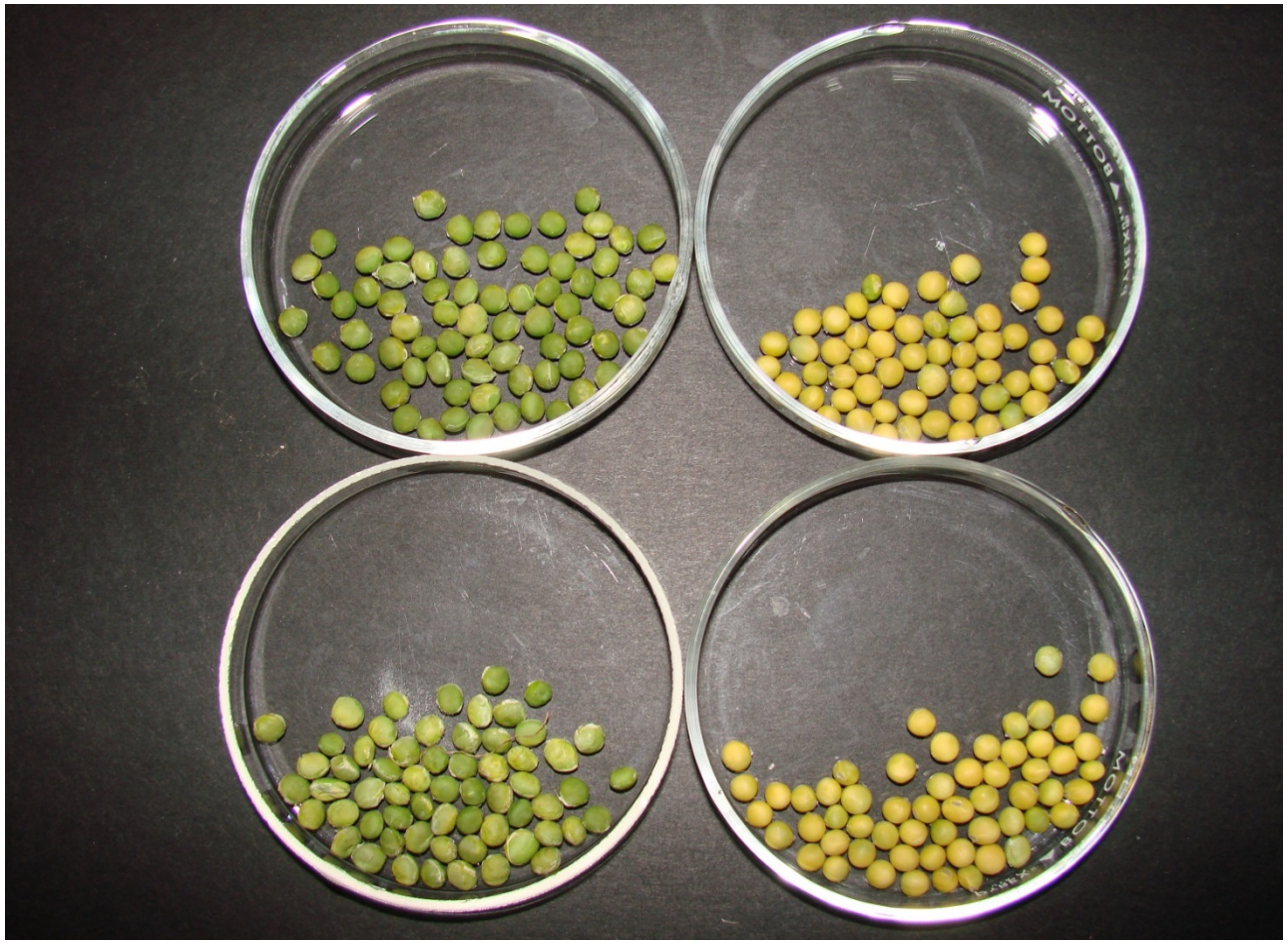
- Drying soybean seeds inside intact pods preserved the germination and vigor of the immature seeds harvested at the full-size (FS) and greenish yellow (GY) pod stages relative to depodded seeds.

- Immature wheat seeds dried in their spikes had higher germination and vigor than those detached and dried under ambient, slow, or fast treatments when seeds were harvested at the milk-stage in two-year experiments.

Samarah et al. (2010). *Seed Sci. & Technol.,* 38, 193-208.

Soybean Harvested at FS Pod Stage

Depodded Dried Seeds **Podded Dried Seeds**



Samarah et al. (2009). *Seed Sci. & Technol.,* 37, 469-473.

Desiccation Tolerance (Germination) of Soybean Harvested at FS Pod Stage

Depodded Dried Seeds

Podded Dried Seeds

Conclusions

- High temperature and severe late drought stress as a result of climate change had a negative impact on food security by increasing the production of immature seeds.
- Depodded, air-dried immature seeds had low germination (desiccation intolerance).
- Depodding, slowly drying the seeds slightly improved seed desiccation tolerance.

Conclusions

- Slowly drying the seeds within pods improved seed desiccation tolerance harvested as early as beginning of seed fill and the vigor of seeds harvested at later developmental stages.

- The improvement in the germination of the podded dried seeds was due to additional gain in dry weight of podded dried seeds or slower drying rate (seed moisture loss rate index of 19 or less).

Implications in Jordan

- Seed producers can harvest common vetch at the greenish-yellow pod stage and maintained high germination and vigor.

- Imbibing seeds at 5^{o}C for 5 days was the most effective method for seed technologists to overcome the dormancy in common vetch seeds.

Implications in Jordan

- The recommended accelerated aging treatment to evaluate seed vigor in common vetch is seed incubation under 100% RH at 39^{o}C for 96 h.

Future Research Needed

- To study the biochemical, physiological, and molecular factors related to seed drying within pods such soluble sugars, late embryogenesis proteins, and antioxidants.

- What is the role of pods in maintaining seed quality?

Future Research Needed

- Can we maintain seed quality of other important legume crops such as soybean by harvesting their pods earlier and dry them artificially?

- Can we think about changing the harvesting practices?

Acknowledgements to Co-Authors

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Thanks For Your Attention