Seed priming in mungbean and chickpea strengthens disease resistance

RIU

Validated RNRRS Output.

Chickpeas sown from primed seed in farmers' fields in Bangladesh have proved to be more resistant to collar rot than chickpeas from seed that was not primed. Likewise, primed mungbean proved resistant to Mungbean Yellow Mosaic Virus in Pakistan. Then, tests in glasshouses showed that primed pearl millet was resistant to Downy Mildew. All this means that priming helps prevent serious damage to pea and bean crops from common diseases. Farmers in the High Barind Tract of Bangladesh and in eastern India now readily prime chickpea seed. They've seen for themselves that primed chickpeas are more resistant to disease than those that aren't primed.

Project Ref: **PSP29:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **CAZS-NR, UK**
Source: **Plant Sciences Programme**

Document Contents:

Description

PSP29

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Bangladesh,

Target Audiences for this content:

Crop farmers,

A. Description of the research output(s)

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Seed priming to improve disease resistance

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Plant Sciences Research Programme (PSP).

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

R7438, R8269, R8221

UK
CAZS Natural Resources, Bangor UK (Dr Dave Harris)

Pakistan
NWFPAU, Peshawar, Pakistan (Prof A. Rashid)

Bangladesh
PROVA, Rajshahi, Bangladesh (Mr A. M. Musa)

India
ICRISAT, Patancheru, AP, India (Dr J.V.D.K. Kumar Rao)

*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 400 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

Seeds of many crops can be primed – soaked in water overnight before sowing –to improve germination, seedling emergence and vigour, growth and yield. Observations in farmers' fields suggested that, in some circumstances, primed crops suffered less damage from some pests and diseases than crops grown from non-primed seed. Field studies between 1999 and 2006 of chickpea and collar rot (*Sclerotium rolfsii*) in Bangladesh and mungbean and Mungbean Yellow Mosaic Virus in Pakistan confirmed that seed priming could increase resistance to those diseases. We also showed that priming pearl millet seeds could increase resistance to Downy Mildew (*Sclerospora graminicola*), at least under glasshouse conditions, although additional studies to identify the physiological mechanism involved in this response have so far proved inconclusive.

It is unlikely that commonly observed yield increases in a wide range of crops from primed seeds are solely the result of increased disease resistance. However, it may be that small increases in resistance contribute 'unseen' in many situations where disease pressure is present at a low level. In addition to promoting innate disease resistance, priming can also be used as a vehicle to treat seeds with crop protection chemicals such as fungicides.

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	Technology	Service	Process or Methodology	Policy	Other Please specify
	X				

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

The studies described in this dossier apply to:

- Chickpea and collar rot (Bangladesh and India)
- Mungbean and Mungbean Yellow Mosaic Virus (Pakistan)
- Pearl millet and Downy Mildew

Other reports, such as those involving rice and Rice Blast, remain unconfirmed

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	High potential	Hillsides	Forest-Agriculture	Peri-urban	Land water	Tropical moist forest	Cross-cutting
X							X

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	Irrigated	Wetland rice based	Smallholder rainfed highland	Smallholder rainfed dry/cold	Dualistic	Coastal artisanal fishing
X		X		X		

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).*

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

This is a cost-effective output that could contribute to crop productivity in general but would be particularly appropriate to take forward with other IPM-related outputs such as those listed below:

- CPP, Increasing food security and improving livelihoods through the promotion of integrated pest and soil management in lowland maize systems Phase II, R8452, R8215
- CPP, Promotion and dissemination of Integrated Pest and Soil Fertility Management strategies to combat striga, stemborers, and declining soil fertility in the Lake Victoria basin., R8449, R8212
- CPP, Strategies for feeding smallholder dairy cattle in intensive maize forage production systems and implications for integrated pest management., R7955
- CPP, Chickpea ICM, R8427, R8366, R7885

Validation

B. Validation of the research output(s)

*10**. How** were the output(s) validated and **who** validated them?*

*Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation **(max. 500 words)**.*

Indian farmers reported that primed **chickpea** suffered less damage from pod borers (Harris *et al*. 1999) and damage in Bangladesh was much reduced but the apparent difference was not statistically significant (Musa *et al.*, 2001). However, damage in farmers' trials caused by collar rot (*Sclerotium rolfsii*) in Bangladesh was significantly reduced by priming seeds overnight, by 45 % in 1998-99 (30 trials) and by 30 % in 1999-00 (35 trials) (Musa *et al.*, 2001).

In an on-station trial in Peshawar, Pakistan in 2002, Rashid *et al*. (2004a) showed that priming seeds of **mungbean** cv. NM 92 for 8 h in water resulted in a significant five-fold increase in grain yield relative to a non-primed crop. This was associated with a large difference in the severity of symptoms of mungbean yellow mosaic virus (MYMV) assessed using a visual scoring index. More than 70 % of the non-primed plants had severe or lethal symptoms whereas only 14 % of the primed plants were similarly affected. Only 9 % of non-primed plants showed no disease symptoms in contrast to 32 % of primed plants. Rashid *et al*. (2004b) also observed similar differences in MYMV infection in other on-station mungbean priming trials.

Downy mildew disease, caused by the obligate biotroph *Sclerospora graminicola* (Sacc.) Schroet. is a major constraint to **pearl millet** yields. A standard greenhouse screening method (Jones *et al*., 1995) was used to investigate the effect of seed priming on the disease resistance of pearl millet. Priming seeds in water for 8 h before sowing significantly reduced the incidence of downy mildew disease in seedlings of a highly susceptible cultivar from about 80 % to less than 60 % (Harris *et al*., 2005). The effect was confirmed in additional glasshouse experiments (unpublished). Although the screen would not allow plants to be assessed at later stages of growth, there is a high degree of correlation between performance of cultivars in the screen and their resistance to downy mildew in the field (Jones *et al.*, 2002). However, a preliminary trial at ICRISAT, India in 2006 failed to confirm this effect in the field.

11. ***Where and when*** *have the output(s) been validated?*

Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above ***(max 300 words)****.*

The effect on disease resistance has only been validated quantitatively by 65 farmers with chickpea in Bangladesh in two seasons (1998-1999 and 1999-2000) although a total of 280 farmers compared primed- with non-primed chickpea using paired-plot trials between 1998 and 2002 in rice-fallows of the High Barind Tract (semi-arid smallholder and sharecropper, rainfed dry).

Effects in other crop-disease systems have only been validated in replicated on-station trials (mungbean for semi-arid, smallholder, rainfed dry) and under glasshouse conditions (pearl millet, usually grown in semi-arid, smallholder, rainfed dry systems).

Current Situation

C. *Current situation*

12. ***How and by whom*** *are the outputs currently being used? Please give a brief description* ***(max. 250 words)****.*

Any disease alleviation due to priming is included in the overall positive priming effect where crops are primed but is not currently explicitly recognised. Priming chickpea seed is a common practice in Bangladesh (Saha, 2002; Socioconsult, 2006) and in eastern India (Kankal et al., 2006) and it is possible that enhanced disease resistance is contributing to the increased yields associated with priming. Similarly, some farmers in Pakistan are priming mungbean seeds so may be benefiting from the same effect.

13. ***Where*** *are the outputs currently being used? As with Question 11 please indicate place(s) and countries* *where the outputs are being used* ***(max. 250 words).***

In theory, if the effect is a real one, it is benefiting farmers wherever they are using primed chickpea seeds and there is disease pressure. If the effect operates in other crop/disease systems then it might be contributing to priming-related yield increases everywhere. Without further specific studies it is difficult to quantify any benefits.

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading ***(max 250 words).***

Priming of chickpea seed was rapidly adopted in the High Barind Tract of Bangladesh (Saha, 2002; Socioconsult, 2006) and in eastern India (Kankal et al., 2006), not because of its specific effects on disease but because of the overall positive effect of priming, which is mainly considered to be improved crop establishment under sub-optimal soil moisture conditions. Rapid spread of the technology will depend on the continued popularity of chickpea as a second crop after rainfed rice and the intensity of promotion efforts for chickpea.

Priming of mungbean in Pakistan is only done by a small number of farmers.

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? ***(max 350 words).***

Farmers have adopted seed priming in chickpea because of its overall benefits, with reduced losses due to disease only one component of that. Successful promotion was a result of making farmers aware of the potential benefits of priming then facilitating them to test the idea for themselves. Existing institutions, e.g. the Department of Agricultural Extension in Bangladesh, can do this effectively if they foster the close linkages with communities espoused by NGOs such as PROVA and use participatory Action Research (PAR). More research on the effects of priming on diseases of other crops would be useful.

Current Promotion

D. Current promotion/uptake pathways

16. ***Where*** *is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion* ***(max 200 words).***

Priming specifically to alleviate disease is not currently being promoted.

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. ***(max 200 words)****.*

Increasing disease resistance is only one of the reasons why seed priming is attractive to farmers, so it is difficult to promote on that basis alone.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words).***

A focussed research programme to quantify effects of priming on disease across crops and locations.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words).***

It is unlikely that seed priming can be promoted on the basis of increased disease resistance alone. For seed priming technology in general, one of the best ways to get to a large number of farmers is to link the technology to a PVS programme. Experience has shown that farmers are very keen to try new varieties. By giving improved cultivars to farmers and asking them to prime some of the seeds they can see the direct and indirect effects for themselves, thus leading to adoption. Use of participatory methods, such as farm walks and field days, is very useful in the validation of the technology as they allow farmers to observe it in a range of familiar situations and can facilitate the effective use of farmers' feedback in fine-tuning it. Participatory approaches also break down barriers between scientists, extension agents and farmers.

Seed priming is an enabling technology – helping to ensure good stands of vigorous plants – and, as such, is an important component of an integrated approach to crop production. Holistic approaches to agricultural development, such as those pursued in rural development programmes or through Farmer Field Schools would be an ideal vehicle for promoting seed priming because its effects open up additional opportunities to apply other technological innovations, such as low-risk use of fertilizer.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

No impact studies have been done specifically on the effects of priming on disease resistance – see Q15 and Q17. Impact studies from Bangladesh and India in relation to elements of chickpea production, including priming are:

Saha, A.K. (2002). Impact assessment study for the DFID-funded project R7540 '*Promotion of Chickpea following*

Rainfed Rice in the Barind Area of Bangladesh'. CAZS Natural Resources, University of Wales, Bangor, UK.

Socioconsult (2006). Report on Impact Assessment Study of Chickpea in the High Barind Tract (HBT). Socioconsult Ltd., SEL Centre, 29 West Panthapath, Dhanmondi, Dhaka.

Kankal, M., Basu, I., Gupta, B., Mishra, K., Gupta, A., Peter, R. and Dash, P. (2006). Agricultural Alternatives - Experiences of Rainfed *Rabi* Cropping in Rice fallows of India. Catholic Relief Services-USCCB, October 2006. pp 33.

21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*
- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

There is no evidence as yet of benefits to the poor from priming specifically through reducing disease in crops. It is possible, however, that benefits due to priming in general will have a component of enhanced disease resistance.

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

Benefits would include less need for agricultural chemicals to manage disease, with decreased production costs and fewer opportunities for human toxicity to farmers and consumers.

Reduced disease incidence in legumes, leading to higher yields, would promote beneficial “legume effects” such as improved soil health and fertility.

*25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? **(max 100 words)***

No adverse effects envisioned.

*26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? **(max 200 words)***

Climate change is likely to change disease patterns, with possible epidemics of new diseases. Priming may be able to help poor people manage these, without increasing reliance on agro-chemicals.

Annex

References

Harris, D., Joshi, A., Khan, P.A., Gothkar, P. and Sodhi, P.S. (1999). On-farm seed priming in semi-arid agriculture: development and evaluation in maize (*Zea mays* L.), rice (*Oryza sativa*) and chickpea (*Cicer arietinum*) in India using participatory methods. *Exp. Agric.* **35**: 15-29.

Harris, D., Breese, W.A. and Kumar Rao, J.V.D.K. (2005). The improvement of crop yield in marginal environments using ‘on-farm’ seed priming: nodulation, nitrogen fixation and disease resistance. Australian Journal of Agricultural Research 56 (11): 1211-1218.

Jones, E.S., Breese, W.A., Liu, C.J., Singh, S.D., Shaw, D.S. and Witcombe, J.R. (2002). Mapping quantitative trait loci for downy mildew resistance in pearl millet: Field and glasshouse screens detect the same QTL. *Crop Sci.* **42**: 1316-1323.

Jones, E.S., Liu, C.J., Gale, M.D., Hash, C.T. and Witcombe, J.R. (1995). Mapping quantitative trait loci for downy mildew resistance in pearl millet. *Theor. Appl. Genetics* **91**: 448-456.

Kankal, M., Basu, I., Gupta, B., Mishra, K., Gupta, A., Peter, R. and Dash, P. (2006). Agricultural Alternatives - Experiences of Rainfed *Rabi* Cropping in Rice fallows of India. Catholic Relief Services-USCCB, October 2006. pp 33.

Musa, A. M., Harris, D., Johansen, C. and Kumar J. (2001). Short duration chickpea to replace fallow after aman rice: the role of on-farm seed priming in the High Barind Tract of Bangladesh. *Experimental Agriculture* 37 (4): 509-521.

Rashid, A., Harris, D., Hollington, P.A. & Ali, S. (2004a). On-farm seed priming reduces yield losses of mungbean (*Vigna radiata*) associated with mungbean yellow mosaic virus in the North West Frontier Province of Pakistan. *Crop Protection* 23: 1119-1124.

Rashid, A., Harris, D., Hollington, P.A. & Rafiq, M. (2004b). Improving the yield of mungbean (*Vigna radiata*) in the North West Frontier Province of Pakistan using on-farm seed priming. *Experimental Agriculture* 40 (2): 233-244.

Saha, A.K. (2002). Impact assessment study for the DFID-funded project R7540 ‘Promotion of Chickpea following Rainfed Rice in the Barind Area of Bangladesh’. CAZS Natural Resources, University of Wales, Bangor, UK.

Socioconsult (2006). Report on Impact Assessment Study of Chickpea in the High Barind Tract (HBT). Socioconsult Ltd., SEL Centre, 29 West Panthapath, Dhanmondi, Dhaka.