Addressing poor nodulation and molybdenum deficiency in chickpea through seed priming

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Abstract

A major limitation to chickpea grown on residual soil moisture after the harvest of rice in the High Barind Tract (HBT) of Bangladesh is acidic surface soil. Multilocational on-farm trials in the 2002-03 season established that grain yield responses to soil-applied 500 g Mo ha^{-1} were 58-173%. However, to develop an application method suitable for resource-poor farmers it was tested if Mo and *Rhizobium* could be added in the seed priming process. Multilocational trials in farmers' fields in 2003-04 confirmed that this was as effective as soil application of Mo, giving yield responses of 37-90 %. In each of 2004-05 and 2005-06 seasons, 50 farmer-implemented on-farm evaluations of adding Mo + *Rhizobium* in the priming solution were conducted in operational scale plots (666 m^2) across the HBT and mean responses of up to 50 %, compared to priming in water only, were obtained. These results suggest that the severe N deficiency of chickpea commonly observed in the HBT can be effectively alleviated by a simple low-cost technology within the scope of resource-poor farmers.

Key Words

Acid soil, *Rhizobium*, nitrogen fixation, on-farm trials, High Barind Tract

Introduction

The High Barind Tract (HBT) in north-western Bangladesh is suitable for growing chickpea (*Cicer arietinum* L.) on residual soil moisture following harvest of rainy season rice in late November to early December. However, surface soils (0-20 cm) are acid (pH<5.5) and this poses limitations to nitrogen fixation. Indeed molybdenum (Mo) deficiency in chickpea in the HBT was demonstrated in 2002, in a nutrient omission experiment at one location, and addition of Mo increased nodulation and N content (Johansen et al. 2004). Subsequently, under a DFID-funded Project (R8269) managed by the University of Wales, on-farm experiments were conducted to determine the extent of Mo deficiency in the HBT and to develop a method of applying Mo and *Rhizobium* inoculum suitable for resource-poor farmers who cultivate chickpea.

Methods

On-farm trials were conducted in 2002-03 at sites with acid surface soils in the northern (Porsha), central (Gomostapur) and southern (Amnura) regions of the HBT. Treatments were applied as follows: 1) Control with recommended agronomic practices for chickpea, including seed priming; 2) As for control, but Mo broadcast on the soil, mixed with river sand, as sodium molybdate at 500 g Mo ha^{-1}; 3) As for control but with soil-applied Mo and *Rhizobium* inoculation of seed. The experiment was laid out in 10 x 10 m plots in a randomized block design in farmers' fields with 5 dispersed replications at each location. Due to absence of compound fertilizers containing Mo in Bangladesh and difficulties of evenly applying the low

rates of Mo salt required to the soil, it was tested as to whether Mo and Rhizobium could be added in the seed priming process. Seed priming, soaking seed in water overnight prior to sowing, had previously been shown to be beneficial for chickpea in the HBT, and had been readily adopted by farmers (Musa et al. 2001). In 2003-04, further on-farm trials were conducted using treatments 1) and 2) as above and also: 3) As for control, but Mo added to the priming water @ 0.5 g sodium molybdate L^{-1} priming solution, ensuring that all seeds were covered with the priming solution and that most of the priming water was absorbed by the seeds after 8 hr; 4) As for 3), but *Rhizobium* inoculum also added to the priming solution at 4 g L^{-1}. Plot size was 7 x 7 m in a randomized block design with 5 dispersed replicates at locations in north (Porsha), central (Gomostapur) and southern (Tanor) HBT. These on-farm trials were researcher-managed and in order to determine if farmers could implement seed priming with Mo and *Rhizobium*, farmer-managed evaluations were conducted. Farmers were given pre-season training in the technology and provided sachets of Mo and *Rhizobium* inoculum. They conducted on-farm evaluations of priming alone versus priming with Mo + Rhizobium in paired plots of 666 m^2. There were 10 such paired comparisons in each of 5 upazilas (sub-districts) in fields having surface soil pH<5.5, in both 2004-05 and 2005-06 seasons. However, due to plot damage by extraneous factors, 7 comparisons had to be discarded from the analysis in 2004-05.

Results

There were significant yield responses to soil application of Mo in 2002-03 across locations, with a further slight but non-significant response to *Rhizobium* application (Table 1). Priming with Mo alone improved yield, but not to the extent of Mo addition to the soil (Table 1). However priming with Mo + *Rhizobium* gave similar yields to soil applied Mo. Nodulation responses showed a similar trend (data not shown). In farmer implemented evaluations, significant yield responses to priming with Mo + *Rhizobium* were obtained across acid surface soil locations of the HBT (Table 2).

Table 1. Effect of adding Mo, with or without *Rhizobium* inoculum (Rh), to the soil or the priming solution on grain yield (t/ha) of chickpea (variety BARI chola 5) in multilocational on-farm trials in the High Barind Tract (HBT) of Bangladesh, in the 2002-03 And 2003-40 seasons.

Treatment	Season and location in HBT							
	2002-03				2003-04			
	North	Central	South	All locations	North	Central	South	All locations
Control	0.37	0.33	0.70	0.47	0.62	0.32	0.67	0.54
Soil Mo	1.01	0.54	1.10	0.88	0.89	0.68	0.96	0.84
Soil Mo+Rh	1.12	0.70	1.13	0.98	-	-	-	-
Primed Mo	-	-	-	-	0.66	0.48	0.93	0.69
Primed Mo+Rh	-	-	-	-	0.93	0.61	0.92	0.82
Standard Error	*0.156*	*0.033*	*0.197*	*0.152*	*0.180*	*0.090*	*0.218*	*0.126*

Significance	P<0.005	P<0.005	ns	P<0.001	ns	P<0.01	ns	P<0.01

Table 2. Response of grain yield (t/ha) of chickpea (variety BARI chola 5) to priming with Mo and *Rhizobium* (Rh) in on-farm evaluations in acid soil locations of the HBT in 2004-05 and 2005-06.

Season	Treatment	Upazila				
		Tanor	Nachole	Gomostapur	Porsha	Shapahar
2004-05	No Mo+Rh	0.599	0.601	0.750	0.513	0.593
	Primed with Mo+Rh[1]	0.655**	0.738**	0.881***	0.637**	0.742***
2005-06	No Mo+Rh	0.762	0.499	0.160	0.700	0.707
	Primed with Mo+Rh[1]	0.761[ns]	0.502 [ns]	0.197***	0.935***	1.058***

Significance of treatment difference: ns = not significant; ** = significant at P<0.01; *** = significant at P<0.001.

Conclusion

Mo deficiency severely limits chickpea in acid soils of the HBT. It can be corrected by adding Mo in the seed priming solution, through which *Rhizobium* inoculum can also be effectively delivered. Thus, severe N deficiency of chickpea commonly observed in the HBT can be alleviated by a simple low-cost technology within the scope of resource-poor farmers.

References

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