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Food and nutritional security through improved production practices in legumes in Afghanistan

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Abstract

Restricted maximum likelihood method was used to assess the performance of introduced improved varieties of chickpea and mungbean (an important plant protein source in Afghanistan) in comparison to local varieties using 272 farmer participatory demonstrations laid out in eight districts of Baghlan, Mazar and Uruzgan provinces in Afghanistan from 2009 to 2012. Effect of these introduced varieties on enhancing food and nutrition security of farmers adopting such technologies was also assessed. On an average and over the analysis period, improved varieties out yielded local ones by 19 and 33% in case of chickpea varieties Madad and Sehat, respectively while in case of mungbean varieties, Mai-2008 and Maash-2008, yielded 19 and 33% more, respectively. Though there is significant yield difference between improved and local varieties of both crops, difference between the improved varieties of chickpea was not significant while it was significant in case of mungbean. The study revealed a non-zero variance component for variety type [improved vs. local] × year within district interaction on the yield of chickpea while none of the interactions in mungbean had positive variance component. Risk analysis showed that with a chosen probability of 90%, the improved varieties yield more than local varieties in both the crops (>1.0 t ha^{-1}). The study highlighted the scope to improve the food and nutrition security in Afghanistan through improved productivity of pulses.

Key words: Food legumes, Afghanistan, Improved varieties, farmer participatory demonstrations, nutritional security

Introduction

Consumption of inadequate amounts of both protein and calories is resulting in the entrenched nutrition and food insecurity for about five million Afghans, with over 20% comprising children under the age of five in Afghanistan (FAO, 2015). Per capita availability of pulses was 2.4 kg in 2013 against the annual per capita requirement of 18.25 kg to fulfill the recommended pulse dietary requirement of 50 gm per capita per day resulting in chronic malnutrition (FAOSTAT, 2016). Limited availability and accessibility of food sources rich in protein,

instability of food supplies, poor diets, etc. are some of the several factors that explain the situation of chronic malnutrition in the country (FAO, 2015). Agriculture sector has been complementing the health sector in terms of making available different foods that are rich in nutrients including vitamins, proteins, amino acids, etc. to the population. Livestock (eggs, meat and dairy products) and food legumes together constitute the major protein sources in Afghanistan (Charity Dirorimwe, 2008). Though chickpea, mungbean, etc. are the important food legumes grown in Afghanistan and rich source of protein, productivity, is less than 1 t ha^{-1} (0.752 t ha^{-1}) and the current production (60,000 t) does not meet the demand of growing human population (FAO, 2016). Huge demand-supply gap constrain their access to these protein sources resulting in food and nutritional insecurity which requires immediate attention. Diversification of wheat based cropping system gives an opportunity to incorporate improved varieties of legumes, released in similar agro-ecologies, in cropping systems in Afghanistan. However, low yields, narrow portfolio of improved varieties, poorly adopted varieties and the associated management practices and non-availability of quality seed are some of the constraints identified in pulses production in Afghanistan (ICARDA IFFVC Baseline Report, 2014). Efforts to select, introduce and popularize high yielding varieties of different pulse crops have been on-going in Afghanistan on fast track mode by international NGOs such as ICARDA. Witcombe et al. (2005); Sharma and Duveiller (2006); Ortiz Ferrara et al. (2007); Thapa et al. (2009); Rizvi et al. (2012); have successfully used farmers' participatory demonstrations in the dissemination of new technologies. Two mungbean (Mai-2008 and Maash-2008) and two chickpea (Sehat and Madad) varieties released by Ministry of Agriculture, Irrigation and Livestock (MAIL) in collaboration with ICARDA are being popularized through farmer participatory demonstrations in Afghanistan. Technological as well as social/cultural factors constrain such efforts in

disseminating new technologies in Afghanistan resulting in adoption lag and yield gaps in farmer fields (Erskine and Nesbitt, 2009). In order to participate in field days on such demonstration plots, women need to take the permission of head of their family or husband (Tavva et al., 2013). In spite of these constraints, farmer participatory demonstrations would be an effective and easy way to convince the farmers on the potential advantages of adopting new technologies and for faster dissemination. An attempt has been made to assess the performance of introduced improved varieties with associated agronomic practices through farmers' participatory demonstrations in comparison with local varieties of chickpea and mungbean and the effect on food and nutritional security.

Materials and methods

The study was conducted in eight districts of Baghlan, Mazar and Uruzgan provinces during four cropping seasons (2009 to 2012) (Table 1). The selection of farmers for laying out on-farm demonstrations was done in close collaboration with the Department of Agriculture and Extension, together with local '*shuras*'[1] and community representatives for the respective districts. The extension agents from the MAIL played an active role in identifying suitable farmers and working with the farmers in laying out the demonstration plots. In addition, support from local community leaders was also crucial in ensuring the secure movement of staff in the target villages. The number of farmers differed in different districts during the four years due to limited availability of progressive farmers who have been cultivating the pulse crops and willing to implement and disseminate the outcomes of on-farm demonstrations to other farmers. A total of 272 farmers' participatory demonstrations (75 for chickpea and 197 for mungbean) were laid out in order to popularize improved varieties of chickpea (Sehat and

[1] a group of senior people in the villages and district, who solve disputes and set priorities for the work required to be done in rural communities

Madad) and mungbean (Mai-2008 and Maash-2008) along with their associated best practices. Each demonstration was laid out in an area of 1000 m^2. Besides the use of improved varieties of crops, best agronomic practices such as the use of seed rate (100 and 50 kg ha^{-1} for chickpea and mungbean respectively), optimum fertilizer (50 kg Urea and 100 kg Di Ammonium Phosphate (DAP) for chickpea and 50 kg Urea and 120 kg DAP for mungbean per ha) and applying weed control methods were included in the demonstrations. It was reported in the ICARDA IFFVC Baseline Report, 2014 that pulse growers need to enhance the knowledge, awareness about GAPs to be followed in the cultivation of different pulse crops. The yields obtained in the demonstrations were compared with the yields obtained by farmers growing local varieties with local agronomic practices. Crops are sown through seed broadcasting and fertilizer application has a wide range (in quantity terms) for both crops. Data collection was restricted to grain yield (crop cutting method) only due to limited skills of the participating farmers in recording data on agronomic traits.

Statistical methods

The yield was modelled as mixed linear model to account for the effect of varieties, districts, year within districts and their interactions. Further, variety factor was partitioned in terms of 'local versus improved' and between improved varieties. Furthermore, the effects of varieties and districts were assumed as fixed, while that of their interactions involving year were assumed random. The model was fitted using REML (restricted maximum likelihood) procedure to estimate fixed effects with their standard errors and variance components of the random effects. The model is described as in the following using the directives of GenStat software (VSN International, 2015).

```
VCOMPONENTS[FIXED=District + Type/Variety] District.Year + District.Year.Type; \
```

```
            cons=positive
REML[PRINT=m,comp, means, devi, wald;  pse=e] Yield
```

where the factors denoted as `Type`, `Variety`, `District`, and `Year` stand for local versus improved variety (two levels), varieties (3), districts (8) and years (4) respectively, and Yield stands for response variable grain yield.

A comparison of improved variety vs. local ones has also been carried out in terms of risk measured by the probability of obtaining a targeted amount of yield using the underlying distribution (Anderson, 1974; Haddad et al., 2005). Amount of risk due to adoption of a technology was estimated by computing the probability of achieving various fixed target yields under observed distributions as well as modelled normal distribution. The risk (1-safety) under a variety with mean M and standard error (S) obtained from N observations was calculated as the probability that the yield in the population of farmers under the variety exceeds τ, a given target. Under the assumption that the yields are normally distributed, the risk can be computed as probability Prob $[t > t_0]$ where $t_0 = (\tau - M)/S$ and the random variable t has t- distribution on N-1 degrees of freedom. The risk curves were drawn by plotting the risks against a range of the target yield values.

Effect of the introduced improved varieties on enhancing food and nutrition security, for adopting farmers was assessed based on the information collected from the secondary data from Afghanistan food balance sheets (FAOSTAT, 2016).

Results

On an average, improved varieties out yielded local ones by 19 and 33% in case of chickpea varieties Madad and Sehat, respectively over the analysis period while in case of mungbean,

Mai- 2008 and Maash-2008, yielded 19 and 31% more, respectively (Table 2). Two improved chickpea cultivars and two mungbean varieties individually and overall yielded significantly higher than the local ones in each of the demonstrations and were also more stable compared to the local varieties over the environments evaluated.

Overall, there is significant yield difference between improved and local varieties in case of chickpea ($p<0.01$). However the two varieties, sehat and madad were not significantly different ($p=0.415$) (Table 3). It is therefore necessary to consider in future that new varieties to be released into the production system should yield significantly higher than the existing varieties unless the new varieties are associated with special traits (for example resistant to diseases) that are of importance to the country as perceived by pulse growers (ICARDA IFFVC baseline Report, 2014). In mungbean, yield difference was not only significant between improved and local varieties ($p<0.01$) but also between the two improved varieties (Mai-2008 and Maash-2008) ($p<0.05$).

Among different interactions analyzed to find out the source of variation in the yield, REML method revealed a non-zero variance component for variety Type × Year within district interaction on the yield of chickpea while none of the interactions in mungbean had positive variance component (Table 4). This indicates that performance of chickpea varieties (improved and local) showed a range of variation over all districts during the four cropping seasons (0.24 to 2.24 t ha^{-1}). The yield of the improved variety was higher than that of the local variety of chickpea in all the districts except in Baghlan-e-sannati (Table 5). However this difference was non-significant ($p=0.159$). In case of mungbean, yield variation across districts during the period under study was in the range of 0.51 to 1.25 t ha^{-1}. Though varieties have been selected and introduced through farmer participatory method (Sperling and Ashby, 2000), many factors are

likely to influence the response of these varieties under farmers' conditions. These factors can be biotic, social, economic, political and infrastructural that influence the performance of specific technologies which are referred to as 'Socio-ecological niche' by Ojiem et al. (2006) and 'Option by context interaction' by Nelson and Coe (2014).

Findings of this study are in agreement with a previous study from Afghanistan (Rizvi et al., 2012) reporting substantial variations for mungbean between improved and local varieties. This study provided similar inference for chickpea.

As evident from Fig. 1 and 2, probability of meeting the target productivity (>1.0 t ha^{-1}) is much higher in case of improved varieties in comparison to local varieties in chickpea and mungbean respectively. The risk curves indicated that in general the improved varieties indeed enhances the production of legumes for those adopting. There is no observed scenario under which they indicate any risk of resulting into poor performing compared to the local varieties. Thus risk analysis showed that with a chosen probability of 90%, the improved varieties yield more than local varieties.

Assuming an adoption of 30% to 50% of the pulses cultivated land with the introduced varieties of chickpea and mungbean in three study provinces, it is likely that per capita availability of these pulses increases by 88 to146 gm per annum. Though this is a small increment considering 18.25 kg annual requirement of pulses, it is certainly a positive step towards achieving nutritional and food security in Afghanistan.

Conclusions

There is a significant yield gain for those farmers who adopts improved varieties over local varieties which not only improves yields but also contributes to food and nutritional security.

Risk assessment indicated positive yield gain in using improved varieties of both chickpea and mungbean. As the onus of popularizing introduced technologies lies with the Department of Extension, Ministry of Agriculture, Irrigation and Livestock (MAIL), efforts should consider to introduce varieties of crops especially chickpea in Afghanistan that have more yield potential than the existing improved varieties to enhance the productivity further. It also highlights the scope to improve the food and nutrition security in Afghanistan through pulses.

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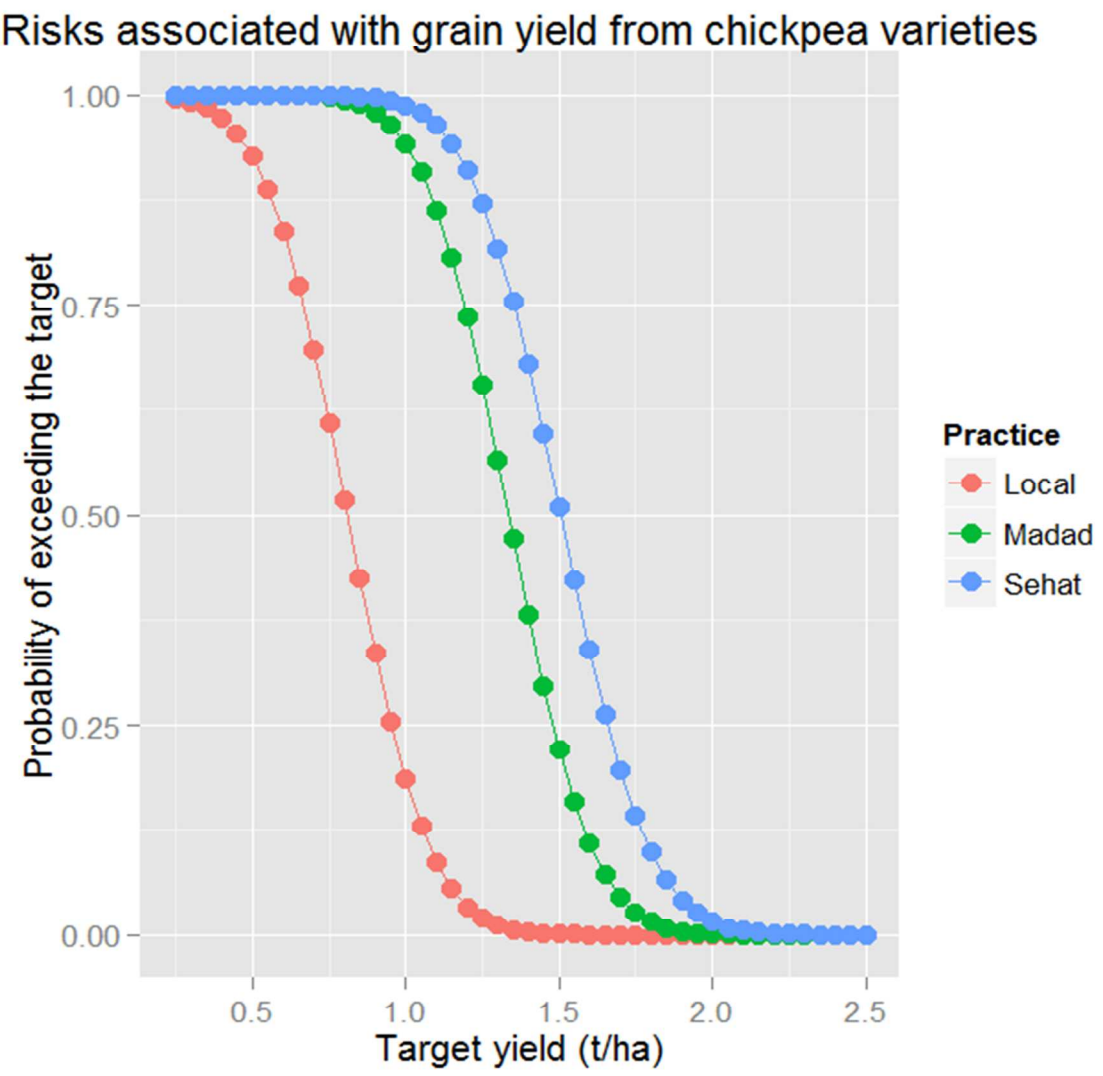

Fig. 1: Risks associated with grain yield from chickpea varieties

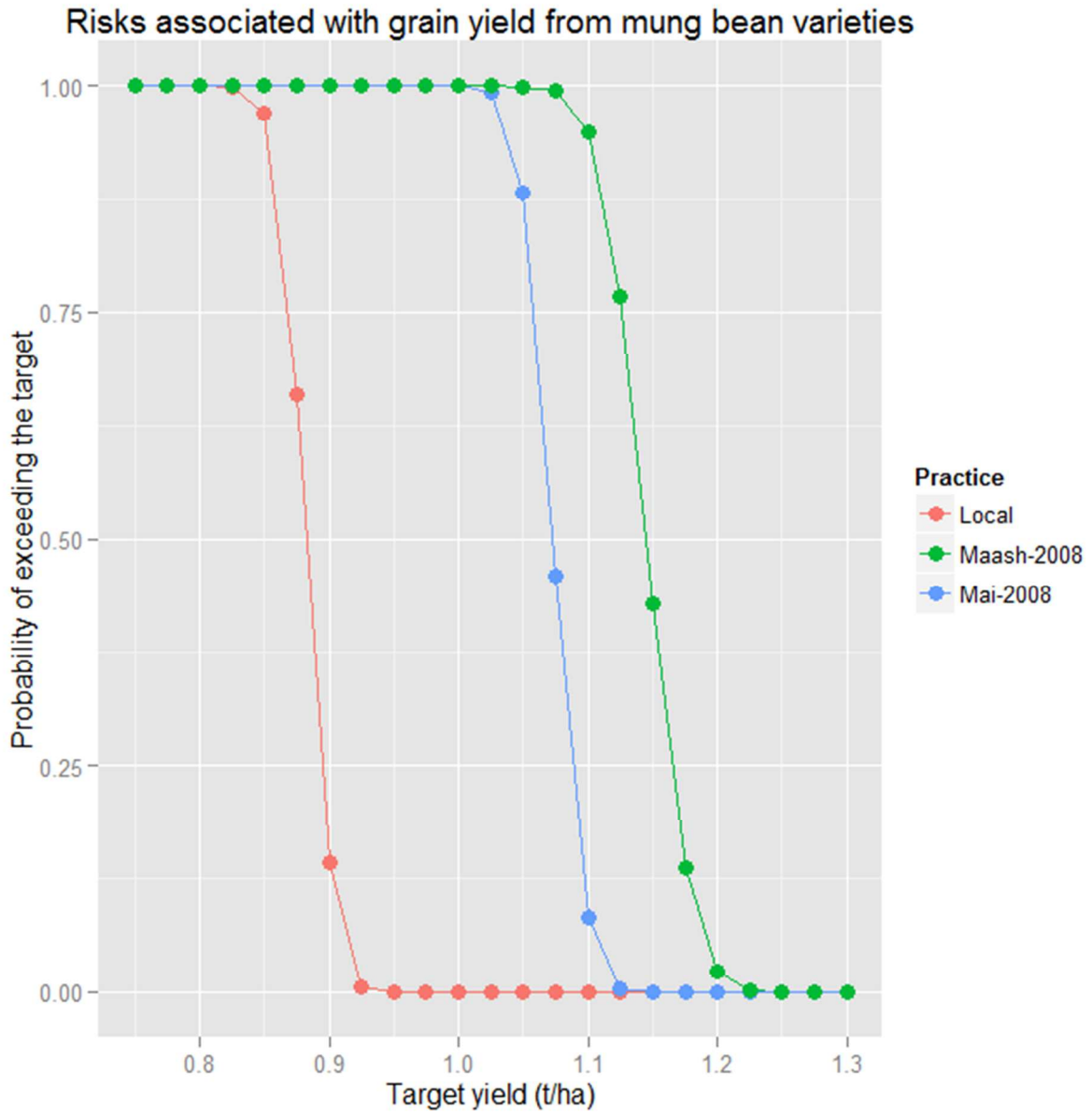

Fig. 2: Risks associated with grain yield from mungbean varieties

Table 1: Number of farmers participatory demonstrations for chickpea and mungbean during 2009-2012 in various districts of the three provinces of Afghanistan

Province	District	Chickpea				Mungbean				Total
		2009	2010	2011	2012	2009	2010	2011	2012	
Baghlan	Baghlan-e-sannati	-	4	-	2	-	30	-	-	36
	Pul-i-khumiri	-	-	-	8	-	9	-	-	17
Mazar-e-sharif	Balkh	5	8	-	-	-	-	-	-	13
	Dawlatabad	5	-	-	-	-	-	-	-	5
	Khulm	5	-	-	-	-	-	-	-	5
	Dehdadi	-	8	-	-	14	26	-	-	48
Uruzgan	Dehrawood	-	-	15	-	-	-	20	39	74
	Trinkote	-	-	15	-	-	-	20	39	74
Total		15	20	30	10	14	65	40	78	272

Source: Author prepared from demonstrations laid out under different projects implemented in Afghanistan in different years.

Table 2: Estimated mean yields of varieties over all the districts (2009-2012)

Crop	Variety	Mean (t ha^{-1})	Standard Error (SE)
Chickpea	Madad	1.335	0.215
	Sehat	1.506	0.227
	Local	0.809	0.213
Mungbean	Mai-2008	1.073	0.019
	Maash-2008	1.145	0.027
	Local	0.882	0.017

Source of the table: Own elaboration (2009-2012)

Table 3: Significance in terms of p-value for variety differences

Crop	Source (varieties)	d.f (numerator)	d.f (denominator	F-statistic	F-probability
Chickpea	Improved vs Local	1	5.6	18.82*	0.006
	Between improved	1	21.6	0.69 ns	0.415
Mungbean	Improved vs Local	1	373	117.00*	<0.001
	Between improved	1	373	4.74**	0.03

*significant at 1%; ** significant at 5%, ns no significant
Source: Author calculations

Table 4: Estimates of variance components due to year within districts and interaction with varieties

Crop	Variance components	Estimates	Standard Error (SE)
Chickpea	Year within districts	0.297	0.357
	(Improved vs Local) × Year within districts interaction	0.060	0.044
	Residual	0.065	0.009
Mungbean	Residual	0.039	0.003

Source: Author compilation of results from analysis

Table 5: Comparative performance of local and improved varieties of chickpea and mungbean in eight districts of Afghanistan averaged over four years, 2009–2012

District	Chickpea (t ha^{-1})			Mungbean (t ha^{-1})		
	Sehat	Madad	Local	Mai-	Maash-2008	Local
Balkh	1.13	1.32	0.53	-	-	-
Khulm	1.46	-	0.83	-	-	-
Dawlatabad	1.28	-	0.81	-	-	-
Dehdadi	1.48	-	0.24	0.69	-	0.51
Baghlan_e_sannati	1.45	1.68	1.94	1.09	-	1.06
Pul-i-khumiri	-	2.25	1.93	1.11	-	1.07
Dehrawood	-	0.88	-	1.25	1.22	0.93
Trinkote	-	0.89	-	1.24	1.24	0.95

Source: Author prepared from demonstrations laid out under different projects implemented in Afghanistan in different years.