Indian Journal of Agricultural Sciences **89** (1): 165–8, January 2019/Short Communication

Economical optimum dose of phosphorus for mungbean (*Vigna radiata*) under contrasting tillage practices in arid region

RAZ MOHAMMAD STORI[1], C M PARIHAR[2], SADEQULLAH AHMADI[3], KHAL MOHAMMAD AHMADZAI[4], H S NAYAK[5], S L JAT[6], B N MANDAL[7], MOHAMMAD KHAN WASIFHY[8], SAYED AHMAD SAYEDI[9], ABDUL BARI SHAMSI[10], QUDRATULLAH EHSAN[11], M D PARIHAR[12], LALIT KUMAR[13] and B R MEENA[14]

Afghanistan National Agricultural Science and Technology University (ANSTU), Kandahar, Afghanistan; and

ICAR-Indian Agricultural Research Institute, New Delhi 110012

Received:06 September 2018; Accepted: 08 October 2018

Key words: Conservation tillage, Monetary efficiency, Phosphorus-use efficiency, Production efficiency, 4 R in conservation tillage, Zero tillage

Due to the dominancy of cereal based nutrition malnutrition is an important health concern in developing countries like Afghanistan. Pulses play a very important role in the food security of Afghanistan and provide easily digestible protein, especially for poor mass of the country. Therefore, pulses are considered as a foremost part of vegetarian food in the country due to high content of protein and lower prices in market as compared to animal protein sources *viz*. fish, eggs, meat and milk products. Pulses have 10 to 15 times more protein than potato and 3 to 4 times more than rice (Mian 1976). Among the pulses, mungbean [*Vigna radiata* (L.) Wilczek] is one of the key pulse crops of Afghanistan. Being a short duration and drought tolerant crop, it is well suited to low rainfall areas and well fits into the existing cropping systems of the country (Noorzai *et al.* 2017). Tillage and crop establishment practices are one of the primary agro-technical operations in agriculture because of its significant influence on soil properties, micro environment and crop performance. Since continuous tilling of soil adversely affects the soil properties, hence it is important to follow suitable tillage practices which restore and improve the soil health as well as sustain and improve the crop yield. Tillage requirement of any crop depends on soil type, nature of the crop, etc. In general, crop requires optimum soil tilth and soil moisture for better seedling emergence and crop growth. The mungbean can be grown without any preparatory tillage on relatively light-textured soils because of its hardy nature and quick growing habit, provided weed growth kept under check at initial growth stages. Under such scenario, conservation agriculture (CA) can bring a paradigm shift from unsustainable to sustainable agriculture and improved the livelihood opportunities and can enhance the quality of the millions of small and marginal farmers living in abject poverty. CA based systems are gaining attention in recent years with the rising concerns of natural resource degradation, energy, water and labour crises, instability in crop yields, high production costs, lower water productivity and nutrient-use efficiency and adverse effects of climate change. CA practices like zero tillage (ZT), raised bed planting and residue management have been found to be the potential resource conservation technologies (RCTs) which can play a vital role to save the scarce natural resources like land, nutrient and water. Recent studies have shown that permanent bed (PB) planting is suitable for enhancing crop productivity and reducing the production cost as well as to conserve the natural resources (Jat *et al.* 2013 and Parihar *et al.* 2016).

Phosphorus (P) is an important essential macro-element required for normal growth and development of pulse crops. Mungbean is highly responsive to applied phosphatic fertilization and significantly increases the growth, yield parameters and yield. Phosphours nutrition plays a vital role in many plant physiological processes, an essential constituent for nucleoprotein, phospholipids enzymes and

[1]MSc Scholar (e mail: raz.storai@gmail.com), ANASTU ,[2]Scientist (e mail: pariharcm@gmail.com), ICAR-IARI; [3]Associate Professor (e mail: sadequllah15@gmail.com), ANASTU; [4]Professor (e mail: ahmadzaikhalmohammad@gmail.com) - ANASTU; [5]MSc Scholar (e mail: 1996harisankar@gmail.com) ICAR-IARI; [6]Scientist (e mail: sliari@gmail.com), ICAR-IIMR [7]Scientist (e mail: mandal.stat@gmail.com), ICAR-IASRI; [8]M Sc Scholar (e mail: m.wasifhy@gmail.com); [9]Assistant Professor (e mail: sayed_50099@yahoo.com), Kandahar University;[10]MSc Scholar (e mail: bari.shamsi@gmail.com), ANASTU; [11]MSc Scholar (e mail: qudrat.ehsan@gmail.com), ANASTU; [12]Junior Agronomist (e mail: mdparihar1205@gmail.com), CCSHAU, Hisar; [13]Scientist (e mail: lalitgoliyan81@gmail.com), Fertilizer Association of India;[14]Ph D Scholar (e mail: brmiari@gmail.com), ICAR-IARI.

other plant substances. It is also essential for translocation of carbohydrates, root development, plant metabolic activities, and influences nutrient uptake by promoting root growth, and nodulation activities. Conservation tillage like zero tillage changes soil health and hence nutrient dynamics. 4R stewardship is an important aspect in nutrient management (IPNI 2012). Right dose of nutrient is important for achieving higher yield. Optimum doses of fertilizer may changes with tillage practices as it alters nutrient dynamics by restricting or enhancing mineralization. Yield attributing characters also changes with tillage practices, and hence affect production and monetary efficiency. Keeping all these points in mind a field study was planned, 1) to establish the relationship between yield attributing characters and yield over the variable doses of P by using correlation and linear regression, 2) to find out the production and monetary efficiency and 3) to quantify the economical optimum dose of phosphorus for mungbean under contrasting tillage practices in Kandahar region of Afghanistan.

A field experiment was conducted at the experimental farm of Afghanistan National Agricultural Science and Technology University, Kandahar, Afghanistan (31°30' N, 65°50' E and 1010 m above the mean sea level) during summer 2017. The site has arid climate characterized by little precipitation and high variation between summer and winter temperatures with annual mean temperature 18.5°C. Average monthly temperature in Kandahar is 26.8 °C. The NM-94 genotype of mungbean was used in the study. Analysis of initial soil samples reveals that soil had 44.1% sand, 10.3% silt and 45.6% clay and classified as clay soil. The experiment consisted of 12 treatment combinations with 3-tillage practices/crop establishment practices, viz. raised bed (RB), zero till flat (ZT) and conventional tillage (CT) in main plots and four P doses in sub-plots, viz. absolute control (0), 40 kg P_2O_5/ha, 60 kg P_2O_5/ha, and 80 kg P_2O_5/ha, and was laid out in a split-plot design and replicated thrice. Nitrogen was uniformly applied @ 35 kg N/ha in all plots as basal through Urea. The source of P_2O_5 was triple super phosphate and was applied as basal. The crop was sown with spacing of 15cm × 10cm. The yield attributes were recorded at harvest from ten plants of individual plot. The seed yield was recorded from net plot and converted into seed yield kg/ha.

The currency used was Afghani (AFN) to work out optimum dose and monetary efficiency. Production efficiency and monetary efficiency were calculated per day basis. A second order polynomial regression ($y=ax^2+bx+c$) was fitted between doses of P_2O_5 applied and yield of mungbean. Significance of partial regression coefficients and R^2 values were found. Economic optimum dose was found out by equating first order derivative of the fitted quadratic equation to ratio of input price and output price. Cost per kg of P_2O_5 was calculated taking per kg price of TSP as 32 AFN. From the economic optimum dose, the yield at optimum dose was found out from the fitted quadratic equation. Than by subtracting the yield at zero dose of P_2O_5 from the economic optimum yield, response at optimum dose was calculated. Phosphorus use efficiency (PUE) was calculated by subtracting yield at respective dose from the control yield and dividing it by doses of P applied at 40, 60, 80 kg P_2O_5/ha and at economic optimum dose of P_2O_5. For calculating PUE, P_2O_5 was converted to P. Only the ZT and CT plots were compared to find out economic optimum doses as they have similar land configuration, but the production and monetary efficiency was calculated for all the three RB, ZT and CT. Linear polynomial fitting was done between yield attributing character and yield irrespective of tillage practices over the variable doses of P_2O_5 applied. Simple correlation coefficient was computed between the yield attributing character and yield in ZT and CT separately to find out the character significantly affecting the yield. The data recorded for different parameters were analyzed with the help of analysis of Variance (ANOVA) technique (Gomez and Gomez 1984) for split-plot design using SAS 9.3 Software (SAS Institute, Cary, NC) and regression analysis was performed by using MS Excel.

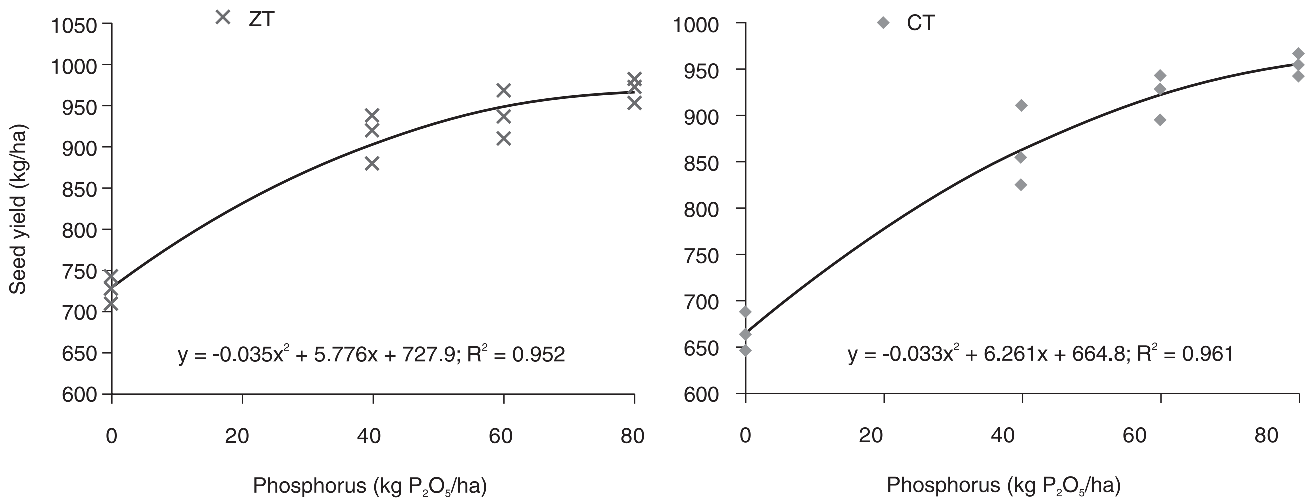

Fig 1 Quadratic regression between seed yield of mungbean and applied phosphorus doses under contrasting tillage practices.

All the 3 partial regression coefficients and regression sum of square were significant at 1% level except the coefficient ‘a’ for CT which is significant at 5% level. R^2 value is 0.952 for ZT and 0.961 for CT, all these describes the quadratic equation (Figure 1) as best fit between doses of P_2O_5 and seed yield for both the tillage practices. The economic optimum dose for ZT was found as 68.15 kg and for CT it was computed as 79.7 kg, and having similar yield at economic optimum dose (958.98, 957.27 kg/ha seed yield, respectively). This clearly demonstrates that under ZT there is option for lowering the P fertilizer dose by about 10 kg P_2O_5/ha with similar yield level.

However the response at economic optimum dose in ZT (231 kg) is less as compared to CT (289.4 kg) because of greater yield in control treatment in ZT plots with better soil environment, simultaneously the PUE at all the level of P fertilizer application is lower in ZT plots as compared to CT plots (Table 1) because of similar reason of greater yield in control plots. From this it can be concluded the efficiency of externally applied P fertilizer decreases in ZT, but availability of inherent soil P increases. Better soil physical and biological property of soil under ZT may be responsible for greater yield in control treatment under ZT plots. All the assumed yield attributing characters are positively correlated to yield, but only pods per plant under ZT plots is significantly correlated to the mungbean yield, however under CT plots pods per plant, seed per pod and dry matter accumulation at 60 DAS is significantly and positively correlated to seed yield of mungbean. Using the linear regression (Table 2) between yield attributing character and seed yield, optimum yield attributing character of mungbean at combined mean economic optimum yield of ~ 959 kg was found as 17 pods/plant and 8 seed/pod with test weight of 46 g.

Production efficiency (kg/ha/day) influenced by different tillage practices and phosphorus levels is presented in (Table 3). Production efficiency was not significant due to different tillage practices, but the higher production efficiency was recorded in raised bed (11.5 kg/ha/day) over zero tillage (11.0 kg/ha/day) and conventional tillage (10.6 kg/ha/day) respectively. Production efficiency was significantly influenced due to phosphorus levels, the leading production efficiency was recorded with 80 kg P_2O_5/ha treated plots (12.3 kg/ha/day) over 60 kg P_2O_5/ha (11.8 kg/ha/day), 40 kg P_2O_5/ha, (11.3 kg/ha/day) and control (8.9 kg/ha/day). Monetary efficiency (AFN/ha/day) was not significantly affected by different tillage practice.

Table 1 Seed yield of mungbean (Y) as a function of phosphorus fertilization ($Y = ax^2 + bx + c$) and Phosphorus (P) use efficiency at different P doses

Parameters		Zero tillage	Conventional tillage
Partial regression coefficient	a	-0.03508**	-0.03301*
	b	5.776**	6.261**
	c	727.95**	664.88**
P value for regression sum of square		<0.01	<0.01
Economic optimum dose(in term of P_2O_5)		68.154	79.789
Yield at optimum dose(kg/ha)		958.98	957.27
Response at optimum dose(kg/ha)		231.084	289.472
Phosphorus (P) use efficiency at 40 kg P_2O_5/ha		10.58	11.34
Phosphorus (P) use efficiency at 60 kg P_2O_5/ha		8.03	9.79
Phosphorus (P) use efficiency at 80 kg P_2O_5/ha		6.96	8.30
Phosphorus (P) use efficiency at economic optima		7.76	8.39

* Significant at 5% level of significance; ** Significant at 1% level of significance

Table 2 Correlation coefficients and linear regression equations showing relationship between mungbean seed yield (kg/ha) and independent variables (X)

Independent variables (X)	Correlation coefficients (r)		Regression equations
	Zero Tillage	Conventional tillage	
Dry matter accumulation at 60 DAS (g/m^2)	0.47858	0.74479*	y = 2.223x + 29.97
Leaf area at 60 DAS (cm^2/plant)	0.54146	0.49194	y = 1.468x - 46.12
Pods/plant	0.91622**	0.88826**	y = 59.16x - 56.85
Seed/pod	0.44614	0.88230**	y = 144.4x - 215.1
Test weight (g)	0.34068	0.26723	y = 20.18x + 23.01

Table 3 Per day productivity and net returns of mungbean under contrasting tillage practices and phosphorus fertilization.

Treatment	Production efficiency (kg/ha/day)	Monitory efficiency (AFN/day)
Tillage practices		
Raised bed	11.5	690.0
Zero tillage	11.1	664.4
Conventional tillage	10.6	615.7
SEm±	0.34	26.3
CD (P=0.05)	NS	NS
Phosphorus rates		
Control	8.9	524.4
40 kg/ha	11.3	676.1
60 kg/ha	11.8	698.3
80 kg/ha	12.3	728.0
SEm±	0.24	17.4
CD (P=0.05)	0.72	52.2

Higher monetary efficiency was also recorded with raised bed practice (690.0 AFN/ha/day) followed by zero tillage (664.4 AFN/ha/day) and conventional tillage practice (615.6 AFN/ha/day). Monetary efficiency was significantly affected due to levels of phosphorus. Maximum monetary efficiency was recorded with 80 kg P_2O_5/ha (727.9 AFN/ha/day) which was statistically superior over 60 kg P_2O_5/ha, 40 kg P_2O_5/ha and 0 kg P_2O_5/ha. This behavior of resources use efficiency under different levels of phosphorus may be traced to the behavior of seed yield of mungbean under different levels of phosphorus. The findings obtained support the results of resource-use efficiency already reported by Kumar and Rana (2007) and Kantwa *et al.* (2005).

SUMMARY

Under ZT planting production and monetary efficiencies are similar and PUE is less as compared to CT plots, but there is a saving of about 10 kg/ha externally applied P_2O_5 fertilizer without any yield penalty. This can lower the cost of cultivation and saves the fertilizer use, however under long-term study in ZT this scenario may be different and ZT may increase PUE as compared to CT plots and doses may also vary for maximum economic benefit. And is the subject for future course of study.

ACKNOWLEDGEMENTS

We sincerely acknowledge the support of Director and Joint Director Education and Dean ICAR-IARI, Head and Professor, Division of Agronomy, ICAR-IARI, New Delhi and Chancellor and other staff of Afghanistan National Agricultural Science and Technology University, Kandahar, Afghanistan and Dr Anupam Verma, Adjunct Professor and INSA Emeritus Scientist for providing all kind of facilities during the study and experimentation period. Special thanks to Mr Sanjeev Kumar for assistance in data management.

REFERENCES

Gomez K A and Gomez A A. 1984. *Statistical Procedures for Agricultural Research,* Second Edition. An International Rice Research Institute Book, A Wiley-Inter-science Publication, John Wiley & Sons, New York.

IPNI. 2012. 4R Plant Nutrition. (*In*) A manual for improving the management of plant nutrition, North American version. Bruuslema T W, Fixen P E and Sulewski G D (Eds). International Plant Nutrition Institute, Norcross, GA, USA.

Jat M L, Gathala M K, Saharawat Y S, Tetarwal J P, Gupta R. and Yadvinder-Singh. 2013. Double no-till and permanent raised beds in maize–wheat rotation of north-western Indo-Gangetic Plains of India: effects on crop yields, water productivity, profitability and soil physical properties. *Field Crops Research,* **149:** 291–9.

Kantwa S R , Ahlawat I P S. and Gangaiah B. 2005. Effect of land configuration, post-monsoon irrigation and phosphorus on performance of sole and intercropped pigeon pea (*Cajanus cajan*). *Indian Journal of Agronomy* **50**(4): 278–80.

Kumar, Ajay and Rana K S. 2007. Performance of pigeonpea (*Cajanus cajan*) + greengram (*Phaseolus radiata*) intercropped system as influenced by moisture conservation practice and fertility level under rainfed conditions. *Indian Journal of Agronomy* **52**(1): 31–5.

Mian A L. 1976. Grow more pulses to keep your pulses well: An assay of Bangladesh pulses. Department of Agronomy, Bangladesh Agriculture University, Mymensingh, p 11–5.

Noorzai A U, Choudhary A K, Bana R S and Prasad R. 2017. Growth behavior, productivity and profitability of promising mungbean varieties in semi-arid region of Afghanistan. *Ann. Agric. Res* **38** (1): 78–86.

Parihar C M, Jat S L, Singh A K, Kumar B, Yadvinder-Singh, Pradhan S, Pooniya V, Dhauja A, Chaudhary V, Jat M L, Jat R K and Yadav O P. 2016. Conservation agriculture in irrigated intensive maize-based systems of north-western India: effects on crop yields, water productivity and economic profitability. *Field Crops Research* **193**: 104–16.