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System productivity and economics as influenced by cropping system and nutrient management

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ABSTRACT

A field experiment was conducted during *kharif*, *rabi* and summer 2013–16 at ICAR-IARI, New Delhi to study the effect of cropping systems and nutrient management on productivity of different crops and cropping systems, the impact of nutrient management on nutrient uptake in different crops and cropping systems and to evaluate economics of different cropping systems. Experiments were conducted in split-plot design replicated thrice. The treatments were comprised five cropping systems, i.e. pearl millet-wheat, pearl millet-mustard-cowpea, pearl millet-wheat-bottle gourd, clusterbean-mustard-cowpea, and clusterbean-wheat-bottle gourd and four nutrient management, i.e. control, RDN (recommended dose of nitrogen), 50% RDN + 50% N through FYM, and 50% RDN + 50% N through FYM + biofertilizers. All the recommended practices except treatment were adopted. The soil test value based nutrient application was done. Results revealed that maximum pearl millet equivalent yield (13.8 t/ha), production efficiency (37.8 kg/ha/day), rainfall-use efficiency (4.34 kg/ha-mm), net returns (₹89198) and benefit cost ratio (2.55) were found under the cropping system of pearl millet-mustard-cowpea. Total nitrogen uptake was obtained more under pearl millet-wheat-bottle gourd. The nutrient management practice of RDN gave higher pearl millet equivalent yield (13.5 t/ha), production efficiency (37 kg/ha/day), rainfall-use efficiency (4.25 kg/ha-mm), total N uptake (120.2 kg/ha) and net returns (₹ 80243) but statistically at par with 50% RDN + 50% N-FYM + BF. The highest benefit cost ratio was recorded in 50% RDN + 50% N-FYM + BF (2.07). It is concluded that the cropping system of pearl millet-mustard-cowpea with nutrient management practice of 50% RDN + 50% N-FYM + BF produced significantly higher yields and income.

Keywords: Cropping system, Nutrient management, Pearl millet-equivalent yield, Production efficiency, Rainfall-use efficiency, System economics

Productivity of rainfed areas is constrained by the extreme variability in rainfall and poor nutrient status of the soils. Growing of different crops are practised in semi-arid areas to reduce the risk factor of crop failures due to recurring droughts. The focus on increasing the cropping intensity as well as production per unit area, per unit drop and per unit time is now gaining importance. Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is predominately grown in arid and semi-arid regions of India under rainfed conditions. Clusterbean (*Cyamopsis tetragonoloba* L. Taub.) is a major rainfed crop of arid and semi-arid regions, mostly grown as a mixed crop with pearl millet, mothbean and sesame but the productivity remains low. Indian mustard [*Brassica juncea* (L.) Czernj and Coss.] is one of the major oilseed crops of the country but the production of this crop need to be enhanced to meet the national shortfall, as availability of edible oil in India. Cowpea (*Vigna unguiculata* L. Walp.) is an important crop of semi-arid regions for since its tolerance for sandy soil and low rainfall. Bottle gourd (*Lagenaria siceraria*) is being cultivated in warm climates around the world and the young fruits are edible and are usually cooked as a vegetable. Organic manures have shown significant impacts on productivity of the crops. However, for sustained production and soil health integrated nutrient management comprising inorganic, organic and biofertilizers is suggested. Among biofertilizers, *Rhizobium* seems to have maximum potential, *arbuscular mycorrhiza* (AM) fungus and phosphate-solubilizing bacteria (PSB) offer great promise in the crops to enable the inoculated plants for uptake of nutrients particularly phosphorus and transport of water more efficiently from the soil. The continuous application of inorganic fertilizers even in balanced form may not sustain soil fertility and productivity. However, judicious use of chemical fertilizers in combination with organic manures is required to improve the soil health as well as to achieve sustainable crop production. Thus, balance

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fertilization along with sound crop husbandry offers a great scope for increasing productivity. Keeping these in view, an experiment was undertaken to improve the productivity and profitability of sequence cropping systems with balanced fertilization under rainfed situations.

MATERIALS AND METHODS

The field experiment was conducted during *kharif*, *rabi* and summer 2013–14 to 2015–16 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi situated at 28° 38' N latitude, 77° 09' E longitude and 228 m above mean sea level. The total rainfall received during the cropping period was 1507.2 mm in 2013–14, 892 mm in 2014–15 and 779.9 mm in 2015–16. The experimental soil was sandy loam in texture (61.48% sand, 12.66% silt and 25.86% clay) and slightly alkaline in reaction (*p*H 7.6). The soil was low in organic carbon (0.40%) and available nitrogen (135.4 kg N/ha), medium in available phosphorus (12.8 kg P_2O_5/ha), potassium (178.8 kg K_2O/ha). Experiments were conducted in split-plot design replicated thrice. The treatments were comprised five cropping systems, i.e. pearl millet-wheat, pearl millet-mustard-cowpea, pearl millet-wheat-bottle gourd, clusterbean-mustard-cowpea, and clusterbean-wheat-bottle gourd and four nutrient management "control, RDN (recommended dose of nitrogen), 50% RDN + 50% N through FYM, and 50% RDN + 50% N through FYM + biofertilizers". The soil test value based nutrient application was done. The crop varieties were used as Pusa Composite-443 (pearl millet), RGC-1055 (clusterbean) during *kharif* HD-2967 (wheat), Pusa Vijay (mustard) during *rabi* and Pusa Sukomal (vegetable cowpea), Pusa Naveen (bottle gourd) during summer season. All the recommended agronomic practices except treatment were adopted. To compare the performance of different cropping sequences, economic yield of all the crops were converted into pearl millet-equivalent yield (PEY) based on prevailed market price using the formula: PEY (of a crop) = Yx (Px)/Pj where, Yx is the yield of crop x (t/ha of economic harvest), Px is the price of crop x, and Pj is the price of pearl millet. The economics was calculated on the basis of prevailing market prices of different inputs and outputs. Chemical analysis for estimation of N was done by micro Kjeldahl method. To assess the resource-use efficiency of the system in terms of production efficiency (kg/ha/day) was calculated by dividing total economic yield (PEY) by total duration of crop in cropping system. Rainfall-use efficiency (RUE, kg/ha-mm) was calculated on the basis of crop yield divided by the rainfall received during the crop duration. The collected data on various parameters were compiled and statistically analysed (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Crop performance: Grain yield of pearl millet and clusterbean were not affected due to cropping systems but treatment effects of cropping systems were observed significantly in case of wheat and mustard while it was found non-significant on the yield of vegetable cowpea and bottle gourd. Significantly higher grain yield of wheat and seed yield of mustard were obtained under the cropping system where clusterbean was sown in *kharif* compared to over the pearl millet as preceding crop in both the cropping systems (Table 1). The higher yield of wheat and mustard may be due to clusterbean which provides better soil health to succeeding crop "wheat and mustard". Significant yield difference of the crops was observed due to nutrient management practices (Table 1). Higher grain yield of pearl millet was obtained in the treatment of recommended dose of nitrogen (RDN) followed by 50% RDN + 50% N-FYM + BF, 50% RDN + 50% N-FYM and control. The yield obtained in RDN (3.34 t/ha) was statistically at par with 50% RDN + 50% N-FYM +BF (3.00 t/ha) but significantly higher over the treatment of 50% RDN + 50% N-FYM (2.62 t/ha) and control (2.12 t/ha). The maximum grain yield was observed under the treatment of RDN (1.00 t/ha) and 50% RDN + 50% N-FYM + BF (0.97 t/ha) which were found significantly higher over the treatment of 50% RDN + 50% N-FYM (0.94 t/ha) and control (0.87 t/ha). Integration of inorganic and organic source of nutrients was found most productive and sustainable with better resource-use efficiency in clusterbean+sesame intercropping system under arid region (Meena *et al.* 2009). Yield of wheat was found more in the cropping system of clusterbean-wheat-bottle gourd (4.68 t/ha) and that was significantly higher over the cropping system of pearl millet-wheat (4.22 t/ha) and pearl millet–wheat–bottle gourd (4.21 t/ha). Higher wheat yield was obtained under the treatment of RDN (4.84 t/ha) and 50% RDN + 50% N-FYM +BF (4.65 t/ha) and both were found significant over 50% RDN + 50% N-FYM (4.32 t/ha) and control (3.51 t/ha). The similar trend was also observed in mustard crop in the same set of cropping system and nutrient management treatments. Green pod yield of vegetable cowpea was obtained higher under the cropping system of clusterbean-mustard-cowpea (7.08 t/ha) but statistically at par with pearl millet-mustard-cowpea (6.89 t/ha). The green-pod yield of cowpea were found statistically at par among the nutrient management practice of RDN (7.41 t/ha) and 50% RDN + 50% N-FYM + BF (7.10 t/ha) but significantly higher over 50% RDN + 50% N-FYM (6.68 t/ha) and control (6.18 t/ha). The yield of bottle gourd was obtained higher in the cropping system of clusterbean-wheat-bottle gourd (13.4 t/ha) but it was statistically at par with pearl millet-wheat-bottle gourd (12.7 t/ha). Similarly, the bottle gourd yield was obtained higher in the nutrient management practice of RDN (14.3 t/ha) but again it was also statistically at par with 50% RDN + 50% N-FYM + BF (12.4 t/ha) and higher over 50% RDN + 50% N-FYM (10.4 t/ha) and control (8.4 t/ha).

N uptake: The nitrogen removal by the crop of pearl millet, clusterbean, cowpea and bottle gourd was not deferred because of cropping systems but variation of N uptake was recorded in wheat and mustard crop (Table 1). Significantly higher grain yield of wheat was observed under clusterbean-wheat-bottle gourd (61.7 kg/ha) system over pearl millet-wheat (53.9 kg/ha) and pearl millet-wheat-

Table 1 Yield and N uptake of crops as influenced by cropping system and nutrient management (Pooled mean of three years)

Treatment	Yield (t/ha)						N uptake (kg/ha)					
	Pearl millet	Clusterbean	Wheat	Mustard	Cowpea	Bottle gourd	Pearl millet	Clusterbean	Wheat	Mustard	Cowpea	Bottle gourd
Pearl millet-wheat	2.73		4.22				47.5		53.9			
Pearl millet-mustard-cowpea	2.72			1.89	6.89		48.3			54.9	6.89	
Pearl millet-wheat- bottle gourd	2.72		4.21			12.7	48.8		54.2			12.7
Clusterbean-mustard-cowpea		0.96		1.95	7.08			29.3		56.6	7.08	
Clusterbean-wheat- bottle gourd		0.98	4.68			13.4		29.9	61.7			13.4
SEm±	0.11	0.06	0.16	0.016	0.090	0.37	1.6	0.93	1.86	0.57	0.14	0.65
LSD (P=0.05)	NS	NS	0.49	0.048	NS	NS	NS	NS	5.51	1.66	NS	NS
Nutrient management												
Control	2.12	0.87	3.51	1.67	6.18	8.4	37.6	26.0	45.3	48.5	6.18	8.4
RDN	3.31	1.00	4.84	2.09	7.41	14.32	59.3	30.6	63.7	60.7	7.41	14.32
50% RDN+50% N-FYM	2.62	0.94	4.32	1.84	6.68	10.40	46.5	28.7	55.7	53.4	6.68	10.40
50% RDN+50% N-FYM+BF	3.00	0.97	4.65	1.97	7.10	12.37	53.2	29.0	60.0	57.2	7.10	12.37
SEm±	0.11	0.013	0.092	0.040	0.107	0.66	2.06	0.64	1.233	1.166	0.33	0.65
LSD (P=0.05)	0.33	0.04	0.28	0.14	0.33	1.98	6.53	1.88	3.73	3.53	0.93	1.98

RDN, Recommended dose of nitrogen; N, FYM, Nitrogen through farmyard manure; BF, Biofertilizer.

bottle gourd (54.2 kg/ha). Similarly seed yield of mustard was obtained significantly higher under clusterbean-mustard (56.6 kg/ha) system over pearl millet-mustard-cowpea (54.9 kg/ha). Nutrient management had impacted on N uptake by different crops. Nitrogen uptake by pearl millet crop was found maximum under RDN (59.3 kg/ha) followed by 50% RDN + 50% N-FYM + BF (53.2 kg/ha), 50% RDN + 50% N-FYM (46.5 kg/ha) and control (37.6 kg/ha). Maximum N uptake of clusterbean was obtained under RDN (30.6 kg/ha) and 50% RDN + 50% N-FYM + BF (29.0 kg/ha) which was significantly higher over 50% RDN + 50% N-FYM (28.7 kg/ha) and control (26.0 kg/ha). N uptake of wheat was also obtained under RDN (63.7 kg/ha) but statistically at par with 50% RDN + 50% N-FYM + BF (60.0 kg/ha). Both the treatments were found superior over the 50% RDN + 50% N-FYM and control. Significantly higher N uptake of mustard was observed in RDN (60.7 kg/ha) and 50% RDN + 50% N-FYM + BF (57.2 kg/ha) over 50% RDN + 50% N-FYM (53.4 kg/ha) and control (48.5 kg/ha). Vegetable cowpea had maximum N uptake under the treatment of RDN (7.41 kg/ha) followed by 50% RDN + 50% N-FYM + BF (7.10 kg/ha), 50% RDN + 50% N-FYM (6.68 kg/ha) and control (6.18 kg/ha). Uptake of N by the bottle gourd was maximum under RDN (14.3 kg/ha) and 50% RDN + 50% N-FYM + BF (12.4 kg/ha) which were significantly higher over 50% RDN + 50% N-FYM (10.4 kg/ha) and control (8.4 kg/ha). This could be attributed to the greater availability and supply of nitrogen at higher levels of farmyard manure and fertilizer application (Singh and Singh 2014). Total N uptake of different cropping system (Table 2) was observed highest under pearl millet-wheat-bottle gourd (115.7 kg/ha) followed by pearl millet-mustard-vegetable cowpea (110.1 kg/ha), clusterbean-wheat-bottle gourd (105.0 kg/ha), pearl millet-wheat (101.4 kg/ha) and clusterbean-mustard-vegetable cowpea (93.0 kg/ha). Bhakar *et al.* (2021) revealed that a portion of recommended dose of fertilizer could be substituted by organic sources of nutrients had positive influence on root growth, yield and nutritional composition of fodder crops.

Pearl millet-equivalent yield: The maximum pearl millet equivalent yield (Table 2) was obtained under pearl millet–mustard-vegetable cowpea followed by clusterbean-mustard-vegetable cowpea, clusterbean-wheat-bottle gourd, pearl millet-wheat-bottle gourd and pearl millet-wheat. The pearl millet equivalent yield was statistically at par under the cropping system of pearl millet–mustard-vegetable cowpea (13.8 t/ha), clusterbean-mustard-vegetable cowpea (13.3 t/ha) and clusterbean-wheat-bottle gourd (13.1 t/ha). As far as nutrient management is concerned maximum pearl millet equivalent yield was obtained under RDN (13.5 kg/ha) followed by 50% RDN + 50% N-FYM + BF (12.6 kg/ha) but both were statistically at par and significantly higher over 50% RDN + 50% N-FYM (11.8 kg/ha) and control (9.8 kg/ha). Similar study of integration of inorganic and organic source of nutrients by Parihar *et al.* (2009) increased the pearl millet-equivalent yield. Similarly Singh *et al*. (2018) observed higher yield advantage and efficient resource utilization in wheat + Indian mustard intercropping fertilized with 15% N through FYM +100% RDF.

Production efficiency: Production efficiency of the cropping systems were analysed and observed the highest production efficiency under the cropping system of pearl millet–mustard–vegetable cowpea followed by clusterbean-mustard-vegetable cowpea, clusterbean-wheat-bottle gourd, pearl millet-wheat-bottle gourd and pearl millet-wheat (Table 2). The production efficiency of pearl millet–

Table 2 Pearl millet-equivalent yield, production efficiency, rainfall-use efficiency, total N uptake and economics as influenced by cropping system and nutrient management (Pooled mean of three years)

Treatment	PEY (t/ha)	PE (kg/ha/day)	RUE (kg/ha/mm)	Total N uptake (kg/ha)	*Cost of cultivation (₹/ha)	Net returns (₹/ha)	B:C ratio
Pearl millet-wheat	6.61	18.1	2.08	101.4	27930	30840	1.10
Pearl millet-mustard- cowpea	13.79	37.8	4.34	110.1	34913	89198	2.55
Pearl millet-wheat- bottle gourd	12.91	35.4	4.06	115.7	41895	74745	1.78
Clusterbean-mustard-cowpea	13.34	36.5	4.20	93.0	34913	85148	2.44
Clusterbean-wheat- bottle gourd	13.09	35.9	4.12	105.0	41895	75915	1.81
SEm±	0.293	0.83	0.093	3.556		4818	0.038
LSD (P=0.05)	0.92	2.11	0.26	9.43		11453	0.14
Nutrient management							
Control	9.81	26.9	3.09	87.9	31838	56453	1.77
RDN	13.52	37.0	4.25	120.2	41438	80243	1.94
50% RDN+50% N-FYM	11.81	32.4	3.72	102.6	35157	71133	2.02
50% RDN+50% N-FYM+BF	12.60	34.5	3.96	111.8	36981	76419	2.07
SEm±	0.316	0.843	0.17	2.82		3036.66	0.043
LSD (P=0.05)	0.94	2.46	0.51	8.54		8110	0.11

PEY, Pearl millet-equivalent yield; PE, Production efficiency; RUE, Rainfall-use efficiency; *Data were not analysed statistically.

mustard- vegetable cowpea, clusterbean-mustard-vegetable cowpea and clusterbean-wheat-bottle gourd were found at par statistically. However, the production efficiency of pearl millet–mustard–vegetable cowpea (37.8 kg/ha/day) was significantly higher over the cropping system of pearl millet-wheat-bottle gourd (35.4 kg/ha/day) and pearl millet-wheat (18.1 kg/ha/day). Significantly higher production efficiency was obtained under the nutrient management practice of RDN (37.0 kg/ha/day) and 50% RDN + 50% N-FYM + BF (34.5 kg/ha/day) over 50% RDN + 50% N-FYM (32.4 kg/ha/day) and control (26.9 kg/ha/day). Overall production was increased per unit area and time. Integrated application of 30 kg N + 20 kg P_2O_5 + 6 tonnes farmyard manure/ha to pearl millet increased the production efficiency (Parihar *et al.* 2009).

Rainfall-use efficiency: Significantly higher rainfall-use efficiency (Table 2) was observed in the cropping system of pearl millet-mustard-vegetable cowpea (4.34 kg/ha-mm) over pearl millet-wheat-bottle gourd (4.1 kg/ha-mm) and pearl millet-wheat (2.1 kg/ha-mm) alone but on the other hand the above cropping system was found statistically at par with the cropping system of clusterbean-mustard-vegetable cowpea (4.20 kg/ha-mm) and clusterbean-wheat-bottle gourd (4.12 kg/ha-mm). Rainfall-use efficiency had influenced due to nutrient management practices. Significantly higher rainfall use efficiency was observed under RDN (4.25 kg/ha-mm) over 50% RDN + 50% N-FYM (3.72 kg/ha-mm) and control (3.1 kg/ha-mm) but statistically at par with the treatment of 50% RDN + 50% N-FYM + BF (3.96 kg/ha-mm). Meena *et al.* (2009) also observed significantly higher rainfall-use efficiency in clusterbean + sesame-intercropping system with the application of 20 kg N + 5 tonnes farmyard manure/ha over 40 kg N/ha alone and control.

System economics: As the various crop sequences were evaluated consisting of crops of diverse nature, it was vital to compare the crop sequences on the basis of economics (Table 2). The maximum cost of cultivation of ₹ 41895 was reported in the cropping system of pearl millet-wheat-bottle gourd and clusterbean-wheat-bottle gourd. Whereas the cultivation cost of ₹ 34913 was reported in the cropping system of pearl millet-mustard-cowpea and clusterbean-mustard-cowpea. The least cost of cultivation of ₹ 27930 was recorded in pearl millet-wheat cropping system. The maximum net returns were gained from pearl millet-mustard-cowpea (₹ 89198) followed by clusterbean-mustard-cowpea (₹ 85148), clusterbean-wheat-bottle gourd (₹ 75915), pearl millet-wheat-bottle gourd (₹ 74745) and pearl millet-wheat (₹ 30840). The net return obtained from pearl millet-mustard-cowpea (₹ 89198) was significantly higher over the cropping systems of clusterbean-wheat-bottle gourd (₹ 75915), pearl millet-wheat-bottle gourd (₹ 74745) and pearl millet-wheat (₹ 30840). The higher benefit cost ratio was reported in the cropping system of pearl millet-mustard-cowpea (2.55) followed by clusterbean-mustard-cowpea (2.44), clusterbean-wheat-bottle gourd (1.81), pearl millet-wheat-bottle gourd (1.78) and minimum was in pearl millet-wheat (1.10). The benefit cost ratio obtained from pearl millet-mustard-cowpea (2.55) was significantly higher over the cropping systems of clusterbean-wheat-bottle gourd (1.81), pearl millet-wheat-bottle gourd (1.78) and pearl millet-wheat (1.10) alone. Rathore *et al.* (2015) also reported maximum net returns under clusterbean-mustard cropping system and lowest gross returns under cotton-mustard cropping system compared to fallow-mustard, soybean-mustard, groundnut mustard and sesame-mustard crop sequences. Higher cost of cultivation under nutrient management practices was observed in RDN (₹ 41438) followed by 50% RDN + 50% N-FYM + BF (₹ 36981), 50% RDN + 50% N-FYM (₹ 35157) and control (₹ 31838). The net returns were also observed highest under the nutrient management of RDN (₹ 80243) followed by 50% RDN + 50% N-FYM + BF (₹ 76419), 50% RDN + 50% N-FYM (₹ 71133) and the least was in control (₹ 56453). The net returns obtained under the nutrient-management practice of RDN (₹ 80243) was significantly higher over 50% RDN + 50% N-FYM (₹ 71133) and control (₹ 56453) but statistically at par with 50% RDN + 50% N-FYM + BF (₹ 76419). Integrated use of 20 kg N + 5 tonnes farmyard manure/ha in clusterbean + sesame intercropping system was most productive, remunerative and sustainable with better resource-use efficiency in arid region (Meena *et al.* 2009). Growing of 75% sorghum+25% guar as mixed cropping with 75% RDF + seaweed extract produced nutritionally enriched fodder yield and profitable income (Bhakar *et al.* 2020). The benefit-cost ratio calculated significantly higher under the nutrient-management practice of 50% RDN + 50% N-FYM + BF (2.07) over RDN (1.94) and control (1.77) but statistically at par with 50% RDN + 50% N-FYM (2.02).

From the above, it can be inferred that equally pearl millet-mustard-cowpea and clusterbean-mustard-cowpea are best suited cropping systems with 50% RDN + 50% N-FYM + BF in sandy loam soils under rainfed conditions.

REFERENCES

Bhakar A, Singh M, Kumar S, Meena R K, Meena B L, Kumar R and Meena V K. 2020. Growth, productivity and profitability of fodder sorghum and cluster bean as influenced by mixed cropping and nutrient management. *Legume Research,* Advanced online publication. https://doi.org/10.18805/LR-4353.

Bhakar A, Singh M, Kumar S, Kumar D, Meena B L, Meena V K and Singh Y V. 2021. Enhancing root traits and quality of sorghum and guar through mixed cropping and nutrient management. *Indian Journal of Agricultural Sciences* **91** (1): 99–104

Meena S L, Shamsudheen M and Devi Dayal. 2009. Productivity of clusterbean (*Cyamopsis tetragonoloba*) and sesame (*Sesamum indicum*) intercropping system under different row ratio and nutrient management in arid region. *Indian Journal of Agricultural Sciences* **79** (11): 901–5

Parihar C M, Rana K S and Parihar M D. 2009. Crop productivity, quality and nutrient uptake of pearl millet (*Pennisetum glaucum*) Indian mustard (*Brassica juncea*) cropping system as influenced by land configuration and direct and residual effect of nutrient management. *Indian Journal of Agricultural Sciences* **79**(11): 927–30

Rathore S S, Shekhawat K, Meena A and Singh D. 2015. Growth, productivity and economics of coral-432 (Indian mustard hybrid) under different cropping systems. *Journal of Oilseed Brassica* **6**(1): 202–8.

Singh R K and Singh A K. 2014. Production potential, nutrient uptake and economics of Indian mustard (*Brassica juncea* L.) under integrated nutrient management practices. *Indian Journal of Agricultural Sciences* **84**: 142–48.

Singh R K, Singh U and Meena R. 2018. Productivity, compatibility and economics of wheat (*Triticum aestivum*) and Indian mustard (*Brassica juncea*) intercropping as influenced by farmyard manure and fertilizer levels under irrigated conditions. *Indian Journal of Agricultural Sciences* **88**(4): 530–9.