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Effect of integrated nitrogen management and planting techniques on the productivity and economics of rain fed pearlmillet + greengram intercropping

Virendra Kumar, RP Singh, Santosh Kumar, UN Shukla and Dinesh Kumar

Abstract
Field experiments were conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U. P. The experiment was laid out in a split plot design consisting 24 treatment combinations replicated thrice. The treatments comprised of four planting techniques *viz.* uniform row, paired row, ridge-furrow and raised bed system and six integrated nitrogen management practices *viz.* 100% RDN (IF) to pearlmillet + no fertilizer to greengram, 100% RDN (IF) to pearlmillet + 100% RDF (IF) to greengram, 25% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram, 50% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram, 75% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram and 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram. Raised bed system being at par with ridge-furrow system showed its significant superiority over paired row and uniform row system in respect of yield attributes, yield, LER, MAI and economics. Application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram was found significantly most effective in increasing yield attributes, yield, economics and productivity over others treatments.

Keywords: Economics, LER, Planting techniques, Productivity

Introduction
Pearlmillet is a predominantly grown under deficient rainfall conditions of eastern Utter Pradesh. In order to minimize the adverse effect of the water logging as a result of intense rains during manson season suitable planting techniques plays a vital role and results into higher crop productivity. Further to compensate the yield losses in *Rabi* due to lower amount of residual moisture in soil profile as well as to enhance the cropping intensity of the system, inclusion of a legume component such as greengram as intercrop between two uniform rows of pearlmillet may be a beneficial alternative. For improving the productivity of both components in the system, adoption of an appropriate land configuration becomes imperative. Planting techniques also plays a vital role in proper crop establishment and efficient use of rain water particularly in rainfed areas (Raddy *et al.*, 2009) [12]. Among agronomic management practices, selection of suitable planting method and nutrient management comprising integrated nutrient management approach are essential to make best use of limited available water resources. Therefore, present investigation was conducted to find out suitable combination of planting techniques with integrated nitrogen management practice in order to optimise economic sustainability. Maintenance of soil fertility is important for obtaining higher sustainable yield due to large turnover of plant nutrient in soil- plant system. Integrated nutrient supply system involving bio-fertilizers, organic manures, crop residues and Vermicompost in conjunction with chemical fertilizers is necessary to meet the crop nutrient demand (Meena and Gautam, 2005) [9]. Vermicompost is rich in plant nutrient materials which contains higher number of micro-organisms responsible for decomposition process (Yami *et. al.*, 2003) [18]. It also improves the physico-chemical properties of soil and enhances the microbial activity for a longer period. Considering these factors, the proposed study was undertaken to see the effect of nutrient and planting techniques on the productivity, economics and nutrient uptake of rainfed pearlmillet + greengram intercropping.

Material and Methods
A field experiment was conducted for two years during *kharif* seasons of 2010 and 2011 at

Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The soil of the experimental site was sandy loam texture with a pH of 7.30. It was moderately fertile, being low in organic carbon (0.35%), available nitrogen (191.12 kg/ha) and medium in available phosphorus (18.60 kg/ha) and potassium (198.15 kg/ha). The experiment was laid out in a split plot design with three replications. Four planting techniques, *viz*. uniform row, paired row, ridged furrow and raised bed planting were allocated to main plot. Six treatments of integrated nitrogen levels *viz*., 100% RDN (IF) to pearlmillet + no fertilizer to greengram, 100% RDN (IF) to pearlmillet + 100% RDF (IF) to greengram, 25% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram, 50% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram, 75% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram and 100% RDN (IF) + 25% RDN (VC) to pearlmillet +100% RDF (IF) to greengram where, RDF represents recommended dose of N, P, K (20–40–20 kg/ha) through inorganic fertilizers to greengram and RDN recommended dose of N (80 kg/ha) through inorganic fertilizers and 25% N (20 kg/ha) through vermicompost and full dose of P, K (40-30 kg/ha) through inorganic fertilizers to pearlmillet were allocated to subplot. Thus, in all total twenty four treatment combinations were replicated thrice. Five additional plots (one plot with all four planting techniques each for sole pearlmillet and one plot for sole greengram) were taken separately for comparison. Nutrients were applied as per treatment wise. Application of vermicompost was done on the basis of its nitrogen content only, ignoring the other nutrients. The pearlmillet cultivar 'TCTP-8203' and greengram cultivar 'HUM-16' were taken as test crops. The other crop management practices were performed as per standard recommendation of the region. Data were recorded on tagged plant in 30 days of interval and yield attributes data were recorded at the time of harvesting. The grain yield of each plot was recorded and converted in hectare. Statistical analysis was done as per the procedures given by Gomez and Gomez (1984) [5].

Results and discussion

Yield of crop

Planting techniques caused significant variation in grain yield of pearlmillet during both the years of study. Maximum grain yield (2061 and 2189 kg ha^{-1}) was recorded with raised bed planting system (P_4), while minimum grain yield (1400 and 1485 kg ha^{-1}) with uniform row system (P_1), respectively during both year of observations. Raised bed ridge-furrow systems proved significantly superior to others in improving the yield of the system and found at par with ridge-furrow system. This might be due to better improvement in N fixation by nodule bacteria and optimum moisture-air equilibrium throughout the crops growth besides supply of available nutrients to the crops, resulting better yield. Similar observations were also noted by Ardeshna *et al.* (2013) [1], Parihar *et al*. (2012) [12], Shete *et al*. (2011) [16].

Among various nitrogen management, application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) produced highest grain yield and proved significantly superior to rest of the levels during both the years of investigation. Similarly, application of 75% RDN (IF) + 25% RDN (VC) to main crop + 100% RDF (IF) to intercrop (F_5) and 100% RDN (IF) to main + 100% RDF (IF) to intercrop (F_2) were found comparable to each other and proved significantly superior to rest of the levels (F_4, F_1, and F_3) during both the years. As discussed, contribution in supplying additional plant nutrients and increasing solubility of native soil nutrients could be the probable reason for efficient and increased partitioning of metabolites and adequate transformation of nutrients to developing plant structures. As a result, almost all yield attributes and yield were significantly influenced by vermicompost combined with 100% RDF (Table 1). These findings are agreement with the results reported by Choudhary *et al*. (2013) [3], Das *et al*. (2013) [4] and Parihar *et al*. (2013) [11].

Pearlmillet equivalent yield (kg ha^{-1})

Data on PEY as influenced by planting techniques clearly indicated that raised bed planting technique recorded maximum PEY which was comparable to ridge-furrow system and both the techniques proved significantly superior to rest of the two systems during both the years (Table 1). Similarly, paired row system was found significantly better than uniform row system in influencing the PEY during both the year of study. However, uniform row planting system was found to be least influencive in respect of their parameter. Among various integrated nutrient levels, application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) recorded maximum PEY which was significantly superior to rest of the nutrient levels during both the years of study. Similarly, F_5 [75% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram] proved significantly better than rest of the four levels (F_2, F_4, F_1 and F_3) during both the years of experimentation. However, F_1 and F_3 were found statistically at par with each other in this attribute during both the years of study.

Table 1: Pearlmillet and greengram yield, pearlmillet equivalent yield (PEY), land equivalent ratio (LER) and monetary advantage index (MAI) as influenced by treatments

Treatment	Yield (kg/ha)						LER		MAI	
	Pearlmillet		Greengram		PEY					
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Planting Technique										
P_1	1400	1485	521	615	3349	3789	1.47	1.51	12479	15029
P_2	1680	1788	610	700	3964	4409	1.66	1.70	18545	21254
P_3	2012	2113	666	770	4504	4997	1.81	1.85	23648	27019
P_4	2061	2189	692	797	4651	5175	1.84	1.89	25034	28598
SE m±	35	36	13	13	83	85	0.03	0.03	968	1003
CD (P=0.05)	122	126	44	45	286	294	0.12	0.11	3349	3470
CV (%)	8.36	8.17	8.66	7.62	8.53	7.85	8.63	8.05	20.61	18.52
Integrated Nitrogen management										
F_1	1581	1662	491	578	3421	3825	1.43	1.46	12176	14366
F_2	1906	2019	634	742	4280	4796	1.77	1.83	22036	25585

F_3	1364	1440	535	630	3367	3800	1.36	1.41	10609	12978
F_4	1691	1777	590	692	3901	4367	1.61	1.65	17381	20242
F_5	2007	2131	729	831	4736	5244	1.94	1.98	27041	30560
F_6	2181	2334	752	851	4997	5522	2.06	2.10	30318	34120
SE m+	40	41	14	15	80	86	0.03	0.03	941	1012
CD (P=0.05)	114	117	41	42	230	245	0.09	0.09	2688	2893
CV (%)	7.70	7.52	7.97	7.03	6.77	6.48	6.73	6.55	16.35	15.26

Sole Greengram yield- 844.47 kg/ha (2010), 935.37 kg/ha (2011)

Sole Pearlmillet yield- P_1= 1648.28 kg/ha (2010), 1736.53 kg h-1 (2011), P_2= 1786.67 kg/ha (2010), 1883.39 kg/ha (2011), P_3= 1973.83 kg/ha (2010), 2053.32 kg h-1 (2011), P_4= 2008.67 kg/ha (2010), 2113.32 kg/ha (2011)

Table 2: Economics as influenced by treatments

Treatment	Cost of cultivation (`/ha)	Gross return (/ha)		Net return (/ha)		B:C ratio	
		2010	2011	2010	2011	2010	2011
	Planting techniques						
P_1	25364	56659	63083	31295	37719	2.23	2.49
P_2	25364	66434	72752	41070	47388	2.62	2.87
P_3	26164	75245	82534	49081	56370	2.88	3.16
P_4	26164	77494	85174	51330	59009	2.97	3.26
SE m+	-	1216	1242	1216	1242	0.05	0.05
CD (P=0.05)	-	4208	4296	4208	4296	0.16	0.16
CV (%)	-	7.48	6.94	11.94	10.51	7.31	6.63
	Integrated nitrogen management						
F_1	21613	57651	63658	36037	42044	2.66	2.94
F_2	24418	71916	79243	47498	54826	2.94	3.24
F_3	26734	56705	63028	29971	36294	2.12	2.35
F_4	27004	65408	72263	38404	45260	2.42	2.67
F_5	27273	78946	86389	51673	59116	2.89	3.16
F_6	27543	83123	90733	55580	63190	3.01	3.29
SE m+	-	1116	1172	1116	1172	0.04	0.04
CD (P=0.05)	-	3190	3350	3190	3350	0.12	0.13
CV (%)	-	5.61	5.35	8.95	8.10	5.39	5.20

Land equivalent ratio (%)

It is apparent from the data that planting techniques had marked influence on LER during both the years of study (Table 1). Raised bed planting system produced highest LER value (1.81 and 1.85 per cent) which was at par with ridge-furrow system and both the techniques resulted into significantly higher LER than rest of the two systems during both the years. Similarly, paired row planting system was found significantly superior to uniform row system which appeared to be most inferior practice of planting in influencing this parameter during both the years. It is clear from the data that there was significant variation in LER due to integrated nutrient levels during both the years of investigation. Among integrated nutrient levels, application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) recorded maximum LER which was significantly superior to other nutrient levels in respect of this attribute during both the years. Similarly, F_5 [75% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram] was also found significantly better than F_2, F_4, F_1 and F_3 levels in respect of this attribute during both year. However, F_1 was statistically at par with F_3 during both years. The higher pearlmillet equivalent yield in raised bed system was due to similar yield of pearlmillet to that of its sole stand, and an additional yield of greengram as a bonus in intercropping system. The results are in accordance with the findings of Kumar *et al*. (2013) [7] and Rao *et al.* (2009) [14].

Economics and monetary advantage index:

The gross return varied markedly due to planting techniques which ultimately influenced the overall net return, B: C ratio (Table 2) and monetary advantage index (MAI) (Table 1). Raised bed planting as well as ridge furrow planting were comparable to each other and significantly recorded higher gross return, net return, B:C ratio and monetary advantage index (MAI) than paired row and uniform row planting system during both the years of experimentation. Similarly, paired row planting system also produced significantly higher gross return than uniform row system during both the years of study. This might be due to marginal difference in pearlmillet yield and additional yield of greengram, which resulted in higher net return in raised bed intercropping system than sole cropping system. Similar results were also reported by Ardeshna *et al.* (2013) [1], Parihar *et al*. (2013) [11] and Mehta *et al*. (2009) [10]. The maximum gross return and net return were recorded with the application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) which was significantly superior to rest of the integrated nutrient levels during both the years. However, B:C ratio indicated that application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) recorded significantly higher B:C ratio as compared to rest of the levels except F_2 which was comparable toF_6 and F_5 during both the years in respect of this monetary attribute. This was mainly because of low cost, higher productivity and better market prices. These findings support those of Singh *et al.* (2013) [17], Kumar *et al*. (2012) [8] and Choudhary *et al*. (2011) [2]. Maximum monetary advantage index (MAI) (Table 1) was realized by the application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_6) during both the years of study. Similarly application of 75% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram (F_5) proved significantly superior to F_2, F_4, F_1 and F_3 levels during both the years. However, F_1 and F_3 appeared to be least effective and these both levels were at par to each other in respect of this monetary parameter during

both the years of study. It can be concluded that raised bed planting system being at par with ridge-furrow system showed its significant superiority over paired row and uniform row systems yield, pearlmillet equivalent yield (PEY), LER, gross return, net return, B:C ratio, MAI. Highest Yield, PEY and LER were found with application of 100% RDN (IF) + 25% RDN (VC) to pearlmillet + 100% RDF (IF) to greengram and it was significantly superior to other treatments.

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