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Response of integrated nutrient management on productivity and nutrient uptake of rainfed pigeonpea based intercropping systems

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Abstract
A field experiment was conducted during the rainy (*kharif*) seasons of 2013-14 and 2014-15 at Agronomy Research Farm, Narendra Deva University of Agricultural and Technology, Kumarganj, Faizabad, Uttar Pradesh on silty loam soils to study the response of integrated nutrient management on productivity and nutrient uptake of rainfed pigeonpea based intercropping systems. The treatments comprised of three intercropping systems of pigeonpea sole, pigeonpea + urdbean (*Vigna mungo* L. Hepper) and pigeonpea + maize (*Zea mays* L.) with different integrated nutrient management levels. On the basis of two years results, pigeonpea + black gram intercropping system recorded significantly higher pigeonpea seed yield (18.65 and 15.82 q/ha), pigeonpea equivalent yield (25.35 and 23.47 q/ha), B:C ratio (2.18 and 2.20, and also gave the total uptake of N, P, K, Zn and Fe by plant, respectively over pigeonpea sole and pigeonpea + maize intercropping system during both year. Among the INM practices, application of RDF+PSB+ *Rhizobium* + FYM @ 3 t/ha + 'Harit-vardan' @ 5 kg/ha recorded significantly higher pigeonpea seed yield (18.65 and 15.82 q/ha), pigeonpea equivalent yield (25.35 and 23.47 q/ha), B:C ratio (2.18 and 2.20, and total uptake of N, P, K, Zn and Fe by plant, respectively over RDF.

Keywords: INM, Pigeonpea, Productivity, Nutrient Uptake Rainfed

Introduction
In India, there is an increasing demand especially for pulses and oil seeds besides cereals to cope up with the increasing human population and to overcome malnutrition in the large section of society. The increasing demand can be met by increasing the productivity through adopting appropriate agronomic practices of which intercropping system is one of the best way to increase production.

Pigeonpea (*Cajanus cajan* (L). Millsp.) is a late maturing, tall growing, wide spaced crop with a deep root system which makes it suitable for intercropping system. Besides, its growth is very slow in the early stage, during which more rapidly growing short duration and short statured crops can be conveniently grown in appropriate row proportion to utilize the natural resources most efficiently in the early stages of pigeonpea. Pigeonpea not only meet the nitrogen demand through atmospheric N fixation but also improve the productivity of soils and has a variety of nitrogen fixing bacteria in its rhizosphere which may release growth promoting substances like indole acetic acid, gibberellins and cytokinin. These substances help in increasing root biomass. Subba Rao (1988) [9] observed that seed inoculation with *Rhizobium* enhanced the productivity of pigeonpea by 16 to 32 per cent under varying agro ecological conditions. The lack of information on these aspects under rainfed conditions made as impetus to undertake the present study. Organic manures and biofertilizers with recommended dose of fertilizers have been reported to be beneficial in augmenting the yield of pigeon pea and black gram (Singh, 2007) [8]. Keeping these points in view a field investigation was carried out to workout suitable nutrient management practice as well as intercropping system for higher productivity, monetary advantage and nutrient uptake in rainfed pigeonpea.

Materials and methods
A field experiment was conducted during rainy (*kharif)* seasons of 2013-14 and 2014-15 at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. (Uttar Pradesh) an India experiment site is situated at 26^0 47' N latitude, 82^0 12' E longitude and at an altitude 113 m above the mean sea level in the Indo-Gangetic alluvial soil belt of Eastern Uttar Pradesh. The soil of the experimental field was silty loam having slight alkaline (*p*H 7.8), EC 0.33 dS/m, poor in organic carbon (0.29%), available nitrogen (164.2 kg) medium in available phosphorus (16.7 kg) and potassium (250.6 kg). The treatment combinations comprised 3 intercropping systems (pigeonpea sole, pigeonpea +

urdbean and pigeonpea + maize) and four nutrient management levels (RDF, RDF + PSB + *Rhizobium*, RDF + PSB + *rhizobium*+ FYM @ 3 t/ha and RDF + PSB + *Rhizobium*+ FYM @ 3 t/ha + 'Harit-vardan' @ 5 kg/ha. The experiment was laid out in a factorial randomized block design with three replications. The required quantity of various organic manures, viz. FYM and 'Harit-vardan biofertilizer were applied in moist soil as per treatment about one week before sowing of crop and at the time of sowing respectively. Seeds of pigeonpea and urdbean were inoculated with *Rhizobium* and PSB before sowing as per treatments. The recommended dose of fertilizers was given for (pigeonpea 20:40:00, urdbean 20:40:00 and maize 80:60:40 kg N: P_2O_5: K_2O/ha) in the form of urea, diammonium phosphate and mureate of potash were applied as basal dose. In case of intercropping treatments, fertilizers were applied in proportionate to the sole optimum population for main crop and intercrop, separately. Weeding and plant protection measures were undertaken as per their need and the required plant population was maintained. 'Narendra Arhar 1', 'Narendra Urd 1' and 'MM 1107' varieties of pigeonpea, urdbean and maize respectively were used. The seed rate of the crops **@** 16 kg/ha (pigeonpea), 20 kg/ha (urdbean) and 25 kg/ha (maize) were sown on 15 June 2013 and 20 June 2014 respectively under rainfed condition. Pigeon pea equivalent yield (PEY) was calculated as follows:

$$\text{Pey (kg/ha)} = \frac{\text{Economic yield of a crop x per kg price of respective crop}}{\text{Price per kg of pigeon pea}}$$

Nutrient uptake in grain and straw of pigeonpea/urdbean/ maize crop were calculated in kg/ha in relation to dry matter production/ha by using the formula.

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{Yield (grain/straw in kg/ha)}}{100}$$

Results and discussion

Pigeonpea+urdbean intercropping system produced significantly higher pigeonpea grain yield (18.65 and 15.52 5 q ha^{-1}), pigeonpea equivalent yield (25.35 and 23.47 q ha^{-1}) and B:C ratio (2.18 and 2.20) as compared to pigeonpea sole and pigeonpea+ maize intercropping system (Table 2). Sizable reduction in pigeon pea yield under pigeon pea + maize intercropping system was due to more competition between maize and pigeon pea for space, nutrients, soil moisture and solar energy. Inclusion of urdbean as intercrop with pigeonpea attributed to less exhaustion of soil fertility, reduced early stage of crop weed competition due to their smoothing effect on weeds as compared to sole pigeonpea and pigeonpea + maize inter cropping, there by increased the yield indices and finally the grain equivalent yield of pigeonpea. Similar results were also reported by Pandey *et al.* (2003) [4], Kumar and Rana (2007) [3]. Amongst integrated nutrient management application of RDF + PSB + *Rhizobium* + FYM @ 3 t/ha + 'Harit-vardan' @ 5 kg/ha recorded maximum grain yield pigeonpea equivalent yield and benefit cast ratio over all the nutrient management system while, which was statistically at par with RDF + PSB + *Rhizobium* + FYM @ 3 t/ha during both the years of study. The increase in yield might be due to the beneficial effect of combined use of organics with balanced inorganic fertilization to the extent of with FYM @ 3 t/ha with 'Harit-vardan' @ 5 kg/ha + RDF + seed inoculation of biofertilizer over RDF alone. These results corroborated the findings of Vyas *et al*. (2006) and Saritha *et al*. (2012) [6].

Table 1: Yield and economically beneficial as influenced by cropping systems and integrated nutrient management

Treatments	Grain yield (q/ha)		Pigeonpea equivalent (q/ha)		B:C ratio	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
A. Inter-cropping system						
C_1	17.07	14.03	17.07	14.03	1.66	1.25
C_2	18.65	15.82	25.35	23.47	2.18	2.20
C_3	12.58	10.98	19.17	18.59	1.34	1.44
SEm ±	0.33	0.39	0.34	0.58	-	-
C D(P=0.05)	0.98	1.15	1.00	1.72	-	-
B. Integrated nutrient management system						
N_1	13.73	11.28	11.25	15.41	1.37	1.16
N_2	15.42	12.76	19.49	17.58	1.67	1.59
N_3	17.2	14.72	21.98	20.32	1.91	1.84
N_4	18.05	15.69	23.08	21.48	1.98	1.97
SEm ±	0.39	0.45	0.39	0.66	-	-
C D(P=0.05)	1.13	1.32	1.60	1.94	-	-

Total nutrient uptake (kg/ha)

Maximum total uptake of nitrogen, phosphorus, potassium, zinc and iron by pigeonpea were recorded under pigeon pea + urdbean intercropping which was significantly higher than pigeon pea sole and pigeon pea + maize intercroppng, during both the years (Table 2). Significantly higher grain yield, yield components and total dry matter production per plant at harvest mainly contributed for higher total uptake of nutrient by pigeon pea in pigeon pea + green gram (1:2) intercropping (Gupta and Rai 1999) [1] also reported similar results. This might be due to set-furrow cultivation that would have created a favorable physical environment for the increased mineralization and mobility of nutrients which was noticed in improvement of available N, P and K contents resulting in higher total nutrient uptake. Patil (1998) [5] revealed that deep tillage and ridging with *Subabul loppings* @ 5 t/ha with 50 kg N/ha recorded significantly higher nutrient availability and uptake of nutrients. Uptake was relatively higher with the application of RDF+PSB+ *Rhizobium*+ FYM @ 3 t/ha + Harit Vardan @ 5 kg/ha which was found significantly higher as compared to RDF alone which was statistically at par with treatment (RDF+PSB+ *Rhizobium* + FYM @ 3 t/ha). This was mainly due to higher biological production and developed root system with enhanced root activity (Sasode, 2006 and Jain *et al*., 2007) [7, 2]. It was also evident that yields were deciding factors for the uptake of nutrient by crop. Moreover, soil organic matter (SOM) is store house of nitrogen, phosphorus and sulphur and there by contributed significantly

to supply of these nutrients to crop plants. It improved various other chemical properties of soil. For example, increased cation exchange capacity helps in trapping nutrient cations like potassium, zinc and iron etc. Apart from nutrient supply, SOM also helps in release of nutrients from the soil. All these are conducive to availability of nutrients and thereby more uptake by crop.

Table 2: Total nutrient uptake as influenced by cropping systems and integrated nutrient management

Treatments	Total nutrients uptake									
	N (kg/ha)		P (kg/ha)		K (kg/ha)		Zn (g/ha)		Fe (g/ha)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
A. Cropping system										
C_1	109.53	86.10	14.71	10.72	57.54	50.08	101.00	78.70	800.41	626.23
C_2	122.42	100.16	17.02	13.16	66.05	60.03	113.90	93.80	900.12	740.84
C_3	82.94	62.42	10.43	8.67	46.42	44.21	76.88	67.54	588.82	493.70
SEm ±	2.55	2.66	0.39	0.31	1.63	1.21	3.17	2.25	17.86	16.49
C D(P=0.05)	7.48	7.80	1.13	0.92	4.78	3.55	9.29	6.61	52.39	48.36
B. Integrated nutrient system										
	81.01	62.83	10.10	7.74	42.53	38.86	101.00	78.70	800.41	626.23
N_2	96.50	75.12	12.75	9.51	51.69	47.02	113.90	93.80	900.12	740.84
N_3	117.03	92.44	16.07	12.35	63.41	57.54	76.88	67.54	588.82	493.70
N_4	125.31	101.19	17.30	13.78	69.05	62.33	3.17	2.25	17.86	16.49
SEm ±	2.94	3.07	0.45	0.36	1.88	1.40	9.29	6.61	52.39	48.36
C D(P=0.05)	8.63	9.01	1.31	1.06	5.51	4.10	101.00	78.70	800.41	626.23

Conclusion

From the above findings, it can be concluded that combined application of RDF+PSB+ *Rhizobium*+ FYM @ 3 t/ha+ Harit Vardan @ 5 kg/ha) is economically beneficial for obtaining higher productivity and economic return of pigeonpea + urdbean intercropping over pigeonpea sole and pigeonpea + maize inter cropping system under rainfed condition during both the years.

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