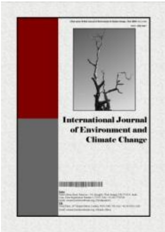

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Effect of Sequential Intercropping Systems and Integrated Nutrient Management on Nutrient Uptake of Pigeonpea

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was carried out during *kharif* and *rabi* seasons of 2019-20 and 2020-21 at ARI, Rajendranagar, Hyderabad to quantify the effect of integrated nutrient management and pigeonpea based sequential intercropping systems on nutrient uptake of the pigeonpea. The experiment was laid out in randomized block design (Factorial) with two factors *i.e*., one with six levels of sequential intercropping systems of pigeonpea (S_1 to S_6) and other with two levels of nutrient management practices (N_1 and N_2 - an integrated approach). Nutrient uptake *viz*., nitrogen, phosphorous and potassium uptakes of pigeonpea crop (grain, stalk and total) was found by using dry matter production and respective nutrient contents at harvesting stage. Sole pigeonpea (S_1) recorded significantly higher mean grain, stalk and total nitrogen, phosphorous and potassium uptake as

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compared to all other sequential inter cropping systems (S_3, S_4, S_5 and S_6) and was statistically at par with S_2. The minimum mean grain, stalk and total nitrogen, phosphorous and potassium uptake was recorded in treatments with sequential intercropping in paired row pigeonpea + sweet corn – safflower (S_6) and paired row pigeonpea + sweet corn – chickpea (S_5) and they were on par with each other. Based on the foregoing findings, it can be inferred that providing nutrients via an integrated method (N_2) rather than fertilisers alone (N_1) increases nutrient availability and, as a result, nutrient uptake.

Keywords: Intercropping system; nutrient management; pigeonpea; chickpea.

1. INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsp., syn. *Cajanus indicus* Spreng), also known as arhar, tur, pigeonpea, congo-pea, no eye pea is the most important *kharif* season crop in India and second most important pulse crop after chickpea. The production of pigeonpea has increased over the years, from 1.72 million tonnes in 1950-51 to 4.25 million tonnes in 2017-18. The increase in production is a result of increase in area from 2.18 million hectares in 1950-51 to around 5.34 million hectares in 2016-17. However, the overall productivity of pigeonpea has remained between 637 to 655 kg ha^{-1} for last several decades [1]. The low yield of pigeonpea is not only due to its cultivation on sub-marginal lands, but also because of inadequate and imbalanced fertilization which decreased the productivity. Inspite of its importance in small hold economy, the crop has not received proper attention for possible yield improvement through agronomical management practices.

Intercropping of short duration crops in the inter space between two rows of a wide spaced crop like pigeonpea that initially grows slowly, can help in better resource utilization and stabilize crop productivity by reducing impact of weather vagaries and increase the cropping intensity [2].

Pigeonpea during *kharif* is generally sown in the month of June - July and it is harvested in the month of December-January. The intercrops sown in *kharif* season like sweetcorn can be harvested in 80-85 days. Many Indian farmers after harvesting of intercrops of pigeonpea, keep the land vacant in between the rows of pigeonpea till the harvesting of pigeonpea. So, there is need to utilise that land for crop production by sowing again with some suitable crops. There is possibility of growing short duration and fast growing crops in between the rows of pigeonpea after the harvesting of *kharif* sown inter crops. This practice of sequential crops for *kharif* inter crops which are sequential inter cropping for pigeonpea is till now not noticed. Nutrient management is the basic factor and is found to exert a great influence not only on growth and yield attributes of crops but also for obtaining sustained productivity. Among all nutrients N, P, K are most important nutrients which contribute to proper growth and yield of crop plant and it also has direct effect on metabolism of plant. In intercropping system, intercrop has lower plant population than its sole crop thus higher dose of nutrients may be helpful in improving yield [3]. Hence, present study was undertaken to see the feasibility of pigeonpea with intercropping of *kharif* and *rabi* season crops in order to make efficient utilization of natural resources under proper agronomic management for higher productivity of crops by limiting competition among the crops. So, it will be beneficial to the farmers by utilizing the land effectively with optimum inputs and harnessing higher income.

In an experiment, Patil and Padmani [4] revealed that application of FYM 5 t ha^{-1} substantially increased the nutrient content as well as uptake of N, P, and K by grain and stalk. In terms of content and uptake of N, P, and K by seed and stalk, pigeonpea crops fertilised with 75 and 100 per cent RDF ha^{-1} were found to be equally effective and significantly superior to 50 per cent RDF ha^{-1}.

Jat and Ahlawat (2004) revealed that the intercropping treatments absorbed more N and P than the sole pigeonpea and groundnut treatments. When comparing sole pigeonpea to pigeonpea + urd bean intercropping, Kumawat et al. [5] found that the pigeonpea + urd bean intercropping method provides significantly higher N, P, and K uptake.

Kumawat et al. [5] conveyed that the sole pigeonpea had the maximum overall uptake of N, P, K, S and Zn, which was equivalent to the standard intercropping system and substantially comparable to the paired intercropping system.

2. MATERIALS AND METHODS

An experiment carried out during *kharif* and *rabi* seasons of 2019-20 and 2020-21 at ARI, Rajendranagar, Hyderabad is located in the Southern agroclimatic zone of Telangana state. The soil was clay in texture, slightly alkaline, low in organic carbon and available nitrogen, medium in available phosphorous and high in available potassium. Pigeonpea variety, TDRG 4 **(**Hanuma), chickpea (NBeG 3) and safflower (Manjeera) from ARS, Tandoor and sweet corn (Sugar-75) from Syngenta Pvt. Ltd., were tested in this experiment [6].

2.1 Climatic Conditions

Geographically, it lies at 17^0 19' 24" N latitude and 78^0 23' 50" E longitude at an altitude of 523 m above mean sea level. During the crop growth period, a total rainfall of 708.8 mm received in 47 rainy days during 2019-20 and 1281.8 mm in 57 days during 2020-21. The daily mean bright sunshine during crop growth period ranged from 1.2 to 10.3 hours with an average of 6.1 hours in 2019-20 season while in 2020-21 season it was ranged from 0.6 to 9.4 hours with an average of 6.0 hours. The daily mean evaporation (mm) during the crop growth period was 3.6 mm during both 2019-20 and 2020-21 seasons.

2.2 Layout of Experiment

The experiment was laid out in Randomized Block design (Factorial) with six sequential intercropping systems [S_1 - Pigeonpea (180 cm), S_2 - Paired row pigeonpea (60-300-60 cm) (With in pair 60 cm and in between pair 300 cm), S_3 - Pigeonpea + Sweetcorn – Chickpea, S_4 - Pigeonpea + Sweetcorn – Safflower, S_5 - Paired row pigeonpea + Sweetcorn – Chickpea and S_6 - Paired row pigeonpea + Sweetcorn – Safflower] and two nutrient management practices [N_1 - 100% RDN and N_2 - 75% RDN + 25% N through FYM – an integrated approach] with three replications. For *kharif* season sown pigeonpea and sweetcorn above mentioned INM treatments (N_1 and N_2) were applied based on plant population.

2.3 Fertilizers Application

Recommended dose of fertilizers (RDF) of pigeonpea – 20:50:00 NPK kg ha^{-1}, sweet corn - 180:60:50 NPK kg ha^{-1}, chickpea - 20:50:20 NPK kg ha^{-1} and safflower - 40:25:00 NPK kg ha^{-1} were applied to the treatments as explained below. Pigeonpea RDF of 20 kg of N and 50 kg of P_2O_5 were applied through urea and single super phosphate respectively as basal dose to the all the plots of pigeonpea as per treatments. RDF of pigeonpea and RDF of sweet corn (plant population basis) were applied to the remaining plots other than sole plots of pigeonpea as per the treatments. Entire P_2O_5 in these treatments was applied as basal dose through single super phosphate (based on population). Entire K_2O through muriate of potash was applied only to the sweet corn in two split doses *i.e*., 50 % as basal dose and 50% at tasseling stage (based on population). RDN of pigeonpea applied as basal dose.

2.4 FYM Application

Quantity of FYM application was decided by content of N in FYM and recommended dose of nitrogen of individual crops. In INM treatment (N_2) of sole planting of pigeonpea (S_1 and S_2), FYM was applied based on recommended dose of nitrogen of pigeonpea @ 909 and 980 kg FYM ha^{-1} during 2019-20 and 2020-21, respectively. When pigeonpea was intercropped with the sweet corn *i.e*., S_3, S_4, S_5 and S_6 in INM treatments, FYM was applied based on recommended dose of nitrogen of both pigeonpea and sweet corn (plant population basis) @ 9091 and 9804 kg FYM ha^{-1} during 2019-20 and 2020-21, respectively.

Chart 1. Available N, P_2O_5, K_2O kg ha^{-1} of soil (Before sowing)

Particulars	Pre-sowing		Method adopted
	2019-20	2020-21	
Available nitrogen (kg N ha^{-1})	226	205.19	Alkaline permanganate method [7]
Available phosphorus (kg P_2O_5 ha^{-1})	48.42	43.24	Olsen's method [8]
Available potassium (kg K_2O ha^{-1})	504.6	469.11	Flame photometer method [9]

Chart 2. Nitrogen content in FYM was analysed chemically by adopting following method

Particular	Method
Nitrogen (%) in FYM 0.55 % (2019-20) 0.51 % (2020-21)	Total nitrogen content (%) in dried FYM samples was determined by kelplus N-analysed (pelican instrument) distillation method after destroying the organic matter using H_2SO_4 and H_2O_2 (Piper, 1966)

2.5 Plant Sample Collection and Analysis

Plant samples from tagged pigeonpea plants were harvested with a sickle slightly above the soil surface. The leaves were separated, and shade dried first, then placed in the oven to dry well. The oven dried plant samples were ground in a willey mill and finely ground samples were kept in labeled butter paper bags. Samples were analyzed for N, P and K content by adapting standard procedures. The values of NPK contents for grain and straw were recorded treatment wise and then N, P and K uptakes were determined for grain and straw yields of each treatments.

2.6 Nitrogen Uptake (kg ha^{-1})

Nitrogen content in plant and grain samples was estimated by modified Kjeldhal's method [6] using automatic kelplus distillation unit after digesting the pigeonpea plant sample in concentrated sulphuric acid and hydrogen peroxide (Piper, 1966) and the nitrogen content is expressed in percentage. N uptake was determined by multiplying dry mater production at harvest by respective percentage of N content in plant and grain samples and transformed into kg ha^{-1}.

$$\text{N uptake (kg ha}^{-1}\text{)} = \frac{\text{N content (\%) x dry matter (kg ha}^{-1}\text{)}}{100}$$

2.7 Phosphorus Uptake (kg ha^{-1})

Phosphorus content was estimated after digesting the pigeonpea plant and grain samples with diacid mixture consisting of nitric acid and perchloric acid in 9:4 ratio. The extract thus obtained is diluted with distilled water and the volume is made up to 50 ml. The phosphorous content in the extract is determined Spectrophotometer (Shimadeu UV-1800 double beam spectrophotometer) at 420 nm by Vanado-Molybdo phosphate yellow colour method as described by Piper (1966) and the phosphorous content is expressed in percentage.

Subsequently P uptake was calculated by multiplying the biological yield of respective treatment with P content in plant and grain samples and transformed into kg ha^{-1}.

$$\text{P uptake (kg ha}^{-1}\text{)} = \frac{\text{P content (\%) x dry matter (kg ha}^{-1}\text{)}}{100}$$

2.8 Potassium Uptake (kg ha^{-1})

Potassium content was estimated after digesting the pigeonpea plant and grain samples with diacid mixture consisting of nitric acid and perchloric acid in 9:4 ratio. The extract thus obtained is diluted with distilled water and the volume is made up to 50 ml. The potassium content in the extract was determined by using Flame photometer (Elico CL 378) as described by Jackson [6] and it is expressed in terms of percentage. The respective K uptake was calculated from plant and grain samples using following formula and converted into kg ha^{-1}

$$\text{K uptake (kg ha}^{-1}\text{)} = \frac{\text{K content (\%) x dry matter (kg ha}^{-1}\text{)}}{100}$$

3. RESULTS AND DISCUSSION

3.1 Nitrogen Uptake

Nitrogen is an essential nutrient to produce amino acids, proteins, nucleic acids, etc., and pigeonpea require an adequate annual supply for proper growth and productivity. The mean grain, stalk and total (grain + stalk) nitrogen uptake was 12.88, 63.39 and 76.44 kg ha^{-1}, respectively. The nitrogen uptake in grain, stalk and total (grain + stalk) as influenced by sequential intercropping systems and integrated nutrient management practices during 2019-20 and 2020-21 were analysed statistically and presented in Table 1.

The data presented in the Table 1 revealed that, the mean grain, stalk and total (grain + stalk) nitrogen uptake was significantly influenced by the sequential intercropping systems during both the years of study. Sole pigeonpea (S_1) recorded significantly higher mean grain, stalk and total nitrogen uptake (16.47, 76.58 and 93.44 kg ha^{-1}, respectively) as compared to all other sequential inter cropping systems (S_3, S_4, S_5 and S_6) and was statistically at par with S_2 (15.01, 71.84 and 86.98 kg ha^{-1}, respectively). The minimum mean grain, stalk and total nitrogen uptake was recorded in treatments with sequential intercropping in paired row pigeonpea + sweet corn – safflower (S_6) (10.31, 53.65 and 64.30 kg ha^{-1}, respectively) and paired row pigeonpea + sweet corn – chickpea (S_5) (10.47, 56.16 and 66.63 kg ha^{-1}, respectively) and they were on par with each other. Nutrient uptake is the function of dry matter production and concentration of that nutrient [10]. The amount of dry matter generated in any crop is primarily determined by photosynthetic efficiency and respiration. The gross amount of dry matter produced in the photosynthesis process is equal to the amount of photosynthates used in the respiration process minus the amount of photosynthates utilised in the respiration process [11]. Likewise, may be due to higher dry matter production and concentration of nitrogen in pigeonpea sown as sole (S_1 and S_2) than pigeonpea with sequential inter cropping systems (S_3, S_4, S_5 and S_6).

Higher mean grain, stalk and total nitrogen uptake was recorded with sequential intercropping in pigeonpea with sweet corn – chickpea (S_3) (12.60, 62.08 and 74.80 kg ha^{-1}, respectively) and pigeonpea with sweet corn – safflower (S_4) (12.45, 60.05 and 72.51 kg ha^{-1}, respectively) than sequential intercropping in paired row pigeonpea with sweet corn – chickpea (S_5) (10.47, 56.16 and 66.63 kg ha^{-1}, respectively) and paired row pigeonpea with sweet corn – safflower (S_6) (10.31, 53.65 and 64.30 kg ha^{-1}, respectively). The results are compatible with those of Patil and Padmani.

Mean grain, stalk and total nitrogen uptake of pigeonpea was shown statistically significant difference between nutrient management practices *i.e*., 100 % RDN through fertilizers (N_1) and 75 % RDN through fertilizers + 25 % RDN through FYM (N_2) – an integrated approach, during both the years (2019-20 and 2020-21). The maximum harvest index was recorded in treatments in which application of 75 % RDN through fertilizers + 25 % RDN through FYM (N_2) (14.60, 68.33 and 83.08 kg ha^{-1}, respectively) over 100 % RDN through fertilizers (N_1) (11.17, 58.46 and 69.80 kg ha^{-1}, respectively). This might be due to integrated application of organic and inorganic nutrient form that resulted higher availability of nitrogen in soil. Along with that higher dry matter production and concentration of nitrogen in N_2 lead to higher nitrogen uptake. Similar results were also observed with Kumawat et al. [5].

3.2 Phosphorous Uptake

The mean grain, straw and total (grain + stalk) phosphorous uptake was 8.64, 7.40 and 16.03 kg ha^{-1}, respectively. The effects of sequential intercropping systems and integrated nutrient management strategies on phosphorous uptake in grain, stalk, and total (grain + stalk) during 2019-20 and 2020-21 were statistically analysed and given in Table 2.

The data presented in the Table 2 revealed that, mean grain, stalk and total (grain + stalk) phosphorous uptake was significantly influenced by the sequential intercropping systems during both the years of study. Sole pigeonpea (S_1) recorded significantly higher mean grain, stalk and total phosphorous uptake (10.69, 8.60 and 19.29 kg ha^{-1}, respectively) as compared to all other sequential inter cropping systems (S_3, S_4, S_5 and S_6) and was statistically at par with S_2 (10.00, 9.16 and 19.17 kg ha^{-1}, respectively). The minimum mean grain, stalk and total phosphorous uptake was recorded in treatments with sequential intercropping in paired row pigeonpea + sweet corn – safflower (S_6) (6.75, 6.12 and 12.88 kg ha^{-1}, respectively) which is on par with the sequential intercropping in paired row pigeonpea + sweet corn – chickpea (S_5) (7.07, 6.18 and 13.25 kg ha^{-1}, respectively). It may be due to higher competition among intercrops for the phosphorous. The higher mean grain, stalk and total phosphorous uptake of sole pigeonpea (S_1 and S_2) than pigeonpea with sequential inter cropping systems (S_3, S_4, S_5 and S_6) may be due to higher dry matter production and concentration of phosphorous in grain and whole plant.

Higher mean grain, stalk and total phosphorous uptake was recorded with sequential intercropping in pigeonpea with sweet corn – chickpea (S_3) (9.02, 7.08 and 16.09 kg ha^{-1}, respectively) and pigeonpea with sweet corn – safflower (S_4) (8.28, 7.25 and 15.53 kg ha^{-1}, respectively) than sequential intercropping in paired row pigeonpea with sweet corn – chickpea (S_5) (7.07, 6.18 and 13.25 kg ha^{-1}, respectively) and paired row pigeonpea + sweet corn – safflower (S_6) (6.75, 6.12 and 12.88 kg ha^{-1}, respectively) during 2019-20 and 2020-21, respectively. It may be due to closer spacing between the two rows of pigeonpea that may cause the more competition among the pigeonpea plants for the phosphorous. The reduced dry matter output of pigeonpea in intercropped treatments could be owing to the sweet corn covering the pigeonpea plants from both sides of each row due to additive intercropping of sweet corn with the pigeonpea. This may enhance intercrop competition for growth factors such as space, light, and water. Reduced leaf area, photosynthesis, and finally dry matter production are all consequences of restricted development (Singh and Pal, 2003). These results were in with the findings of Patil and Padmani (2007).

Mean grain, stalk and total phosphorous uptake of pigeonpea was shown statistically significant difference between nutrient management practices *i.e*., 100% RDN through fertilizers (N_1) and 75% RDN through fertilizers + 25% RDN through FYM (N_2) during both the years (2019-20 and 2020-21). The maximum mean grain, stalk and total phosphorous uptake was recorded in treatments in which application of 75% RDN through fertilizers + 25% RDN through FYM (N_2) (9.10, 8.24 and 17.34 kg ha^{-1}, respectively) over 100% RDN through fertilizers (N_1) (8.17, 6.56 and 14.73 kg ha^{-1}, respectively). FYM application encouraged to release the organic acids and anions into the soil which increases the availability of phosphorous in soil solution (Singh, 2017). Higher phosphorous uptake in N_2 over N_1 may be due to higher availability, dry matter production and concentration of phosphorous in pigeonpea plant. These results were in line with the findings of Kumar and Rana [12].

3.3 Potassium Uptake

Potassium plays major role in regulation of water in plants, activation of enzymes, protein and starch synthesis and imparts drought resistance to plants. Potassium uptake in the grain, stalk, and total (grain + stalk) was 15.51, 24.60, and 40.11 kg ha^{-1}, respectively. The effects of sequential intercropping systems and integrated nutrient management strategies on potassium uptake in grain, stalk, and total (grain + stalk) during 2019-20 and 2020-21 were statistically analysed and given in Table 3.

During both years of the study, the sequential intercropping systems had a substantial impact on the mean grain, stalk, and total potassium uptake, as shown in Table 3. Sole pigeonpea (S_1) recorded significantly higher mean grain, stalk and total potassium uptake (17.90, 29.44 47.34 and kg ha^{-1}, respectively) as compared to sequential inter cropping systems *viz*., S_3, S_4, S_5 and S_6 and was statistically at par with S_2 (17.77, 28.03 and 45.80 kg ha^{-1}, respectively. The minimum mean grain, stalk and total potassium uptake was recorded in treatments with sequential intercropping in paired row pigeonpea + sweet corn – safflower (S_6) (12.56, 20.13 and 32.69 kg ha^{-1}, respectively) which is on par with the sequential intercropping in paired row pigeonpea + sweet corn – chickpea (S_5) (12.77, 20.71 and 33.48 kg ha^{-1}, respectively). The higher mean grain, stalk and total potassium uptake of sole pigeonpea (S_1 and S_2) than pigeonpea with sequential inter cropping systems (S_3, S_4, S_5 and S_6) may be due to higher dry matter production and concentration of potassium in grain and whole plant of pigeonpea.

Higher mean grain, stalk and total potassium uptake was recorded with sequential intercropping in pigeonpea with sweet corn – chickpea (S_3) (16.48, 25.14 and 41.63 kg ha^{-1}, respectively) and pigeonpea with sweet corn – safflower (S_4) (15.55, 24.15 and 39.70, respectively) than sequential intercropping in paired row pigeonpea with sweet corn – chickpea (S_5) (12.77, 20.71 and 33.48 kg ha^{-1}, respectively) and paired row pigeonpea with sweet corn – safflower (S_6) (12.56, 20.13 and 32.69 kg ha^{-1}, respectively) during 2019-20 and 2020-21, respectively. Kumawat *et al*. (2015) also observed similar results where pigeonpea in paired row planting recorded lower total potassium uptake than pigeonpea in normal planting.

Mean grain, stalk and total potassium uptake of pigeonpea was shown statistically significant difference between nutrient management practices *i.e*., 100% RDN through fertilizers (N_1) and 75% RDN through fertilizers + 25% RDN through FYM (N_2) during both the years (2019-20 and 2020-21). The maximum mean grain, stalk and total potassium uptake was recorded in treatments in which application of 75% RDN through fertilizers + 25% RDN through FYM (N_2) (17.18, 27.12 and 44.30 kg ha^{-1}, respectively) over 100% RDN through fertilizers (N_1) (13.83, 22.08 and 35.91 kg ha^{-1}, respectively). Combine application of FYM with inorganic fertilizers increases the availability compared to the treatments in which only inorganic fertilizers

Table 1. Nitrogen uptake (kg ha^{-1}) of pigeonpea as influenced by sequential inter cropping systems and integrated nutrient management practices during 2019-20 and 2020-21

Treatments	Seed			Stalk			Total		
	19-20	20-21	Mean	19-20	20-21	Mean	19-20	20-21	Mean
Sequential intercropping systems (S)									
S_1 - Pigeonpea (180 cm)	15.49	17.45	16.47	74.69	78.46	76.58	90.97	95.91	93.44
S_2 - Paired row pigeonpea (60-300-60 cm)	14.09	15.94	15.01	68.13	75.55	71.84	82.46	91.49	86.98
S_3 - Pigeonpea + Sweetcorn – Chickpea	11.56	13.63	12.60	58.87	65.28	62.08	70.69	78.91	74.80
S_4 - Pigeonpea + Sweetcorn – Safflower	11.52	13.39	12.45	58.14	61.97	60.05	69.65	75.36	72.51
S_5 - Paired row pigeonpea + Sweetcorn – Chickpea	9.74	11.19	10.47	55.17	57.15	56.16	64.91	68.34	66.63
S_6 - Paired row pigeonpea + Sweetcorn – Safflower	10.08	10.55	10.31	53.63	53.67	53.65	64.39	64.22	64.30
S.Em±	0.45	0.53	-	2.07	2.02	-	2.50	2.78	-
CD (p=0.05)	1.31	1.55	-	6.06	5.92	-	7.34	8.15	-
Integrated nutrient management practices (N)									
N_1 - 100 % RDN	10.40	11.95	11.17	56.71	60.20	58.46	67.46	72.15	69.80
N_2 - 75 % RDN + 25 % N through FYM	13.76	15.43	14.60	66.17	70.50	68.33	80.24	85.93	83.08
S.Em±	0.26	0.31	-	1.19	1.17	-	1.44	1.60	-
CD (p=0.05)	0.75	0.90	-	3.50	3.42	-	4.24	4.71	-
Interactions (S x N)									
S.Em±	0.63	0.75	-	2.92	2.86	-	3.54	3.93	-
CD (p=0.05)	NS	NS	-	NS	NS	-	NS	NS	-
General Mean	12.08	13.69	12.88	61.44	65.35	63.39	73.85	79.04	76.44
CV (%)	9.03	9.47	-	8.23	7.57	-	8.30	8.61	-

RDN- Recommended dose of nitrogen through fertilizers; FYM- Farm yard manure

Table 2. Phosphorous uptake (kg ha^{-1}) of pigeonpea as influenced by sequential inter cropping systems and integrated nutrient management practices during 2019-20 and 2020-21

Treatments	**Seed**			**Stalk**			**Total**		
	19-20	**20-21**	**Mean**	**19-20**	**20-21**	**Mean**	**19-20**	**20-21**	**Mean**
Sequential intercropping systems (S)									
S_1 - Pigeonpea (180 cm)	10.04	11.34	10.69	8.39	8.81	8.60	18.42	20.15	19.29
S_2 - Paired row pigeonpea (60-300-60 cm)	9.39	10.62	10.00	8.69	9.64	9.16	18.08	20.26	19.17
S_3 - Pigeonpea + Sweetcorn – Chickpea	8.30	9.74	9.02	6.71	7.44	7.08	15.00	17.18	16.09
S_4 - Pigeonpea + Sweetcorn – Safflower	7.65	8.91	8.28	7.01	7.49	7.25	14.67	16.40	15.53
S_5 - Paired row pigeonpea + Sweetcorn – Chickpea	6.58	7.57	7.07	6.07	6.29	6.18	12.65	13.85	13.25
S_6 - Paired row pigeonpea + Sweetcorn – Safflower	6.60	6.91	6.75	6.12	6.13	6.12	12.72	13.04	12.88
S.Em±	0.30	0.40	-	0.24	0.37	-	0.53	0.56	-
CD (p=0.05)	0.88	1.16	-	0.70	1.08	-	1.56	1.65	-
Integrated nutrient management practices (N)									
N_1 - 100 % RDN	7.61	8.74	8.17	6.36	6.76	6.56	13.96	15.50	14.73
N_2 - 75 % RDN + 25 % N through FYM	8.58	9.62	9.10	7.97	8.51	8.24	16.55	18.13	17.34
S.Em±	0.17	0.23	-	0.14	0.21	-	0.31	0.32	-
CD (p=0.05)	0.51	0.67	-	0.41	0.62	-	0.90	0.95	-
Interactions (S x N)									
S.Em±	0.43	0.56	-	0.34	0.52	-	0.75	0.79	-
CD (p=0.05)	NS	NS	-	NS	NS	-	NS	NS	-
General Mean	8.09	9.18	8.64	7.17	7.63	7.40	15.26	16.81	16.03
CV (%)	9.13	10.58	-	8.18	11.79	-	8.53	8.19	-

RDN- Recommended dose of nitrogen through fertilizers; FYM- Farm yard manure

Table 3. Potassium uptake (kg ha^{-1}) of pigeonpea as influenced by sequential inter cropping systems and integrated nutrient management practices during 2019-20 and 2020-21

Treatments	Seed			Stalk			Total		
	19-20	20-21	Mean	19-20	20-21	Mean	19-20	20-21	Mean
Sequential intercropping systems (S)									
S_1 - Pigeonpea (180 cm)	16.82	18.98	17.90	28.70	30.17	29.44	45.52	49.15	47.34
S_2 - Paired row pigeonpea (60-300-60 cm)	16.67	18.86	17.77	26.59	29.47	28.03	43.26	48.33	45.80
S_3 - Pigeonpea + Sweetcorn – Chickpea	15.14	17.82	16.48	23.84	26.45	25.14	38.99	44.27	41.63
S_4 - Pigeonpea + Sweetcorn – Safflower	14.38	16.72	15.55	23.37	24.93	24.15	37.75	41.65	39.70
S_5 - Paired row pigeonpea + Sweetcorn – Chickpea	11.88	13.65	12.77	20.35	21.07	20.71	32.23	34.72	33.48
S_6 - Paired row pigeonpea + Sweetcorn – Safflower	12.27	12.85	12.56	20.12	20.14	20.13	32.39	32.99	32.69
S.Em±	0.50	0.56	-	0.85	0.85	-	1.32	1.30	-
CD (p=0.05)	1.47	1.64	-	2.50	2.48	-	3.87	3.80	-
Integrated nutrient management practices (N)									
N_1 - 100 % RDN	12.87	14.78	13.83	21.42	22.74	22.08	34.30	37.52	35.91
N_2 - 75 % RDN + 25 % N through FYM	16.18	18.18	17.18	26.24	28.00	27.12	42.42	46.18	44.30
S.Em±	0.29	0.32	-	0.49	0.49	-	0.76	0.75	-
CD (p=0.05)	0.85	0.95	-	1.45	1.43	-	2.23	2.20	-
Interactions (S x N)									
S.Em±	0.71	0.79	-	1.21	1.20	-	1.87	1.83	-
CD (p=0.05)	NS	NS	-	NS	NS	-	NS	NS	-
General Mean	14.53	16.48	15.51	23.83	25.37	24.60	38.36	41.85	40.11
CV (%)	8.43	8.31	-	8.78	8.17	-	8.42	7.59	-

RDN- Recommended dose of nitrogen through fertilizers; FYM- Farm yard manure

applied. This might increase the absorption of nutrients results in increased dry matter production and concentration in plants. Increased dry matter production and concentration of phosphorous in plants increased the phosphorous uptake. These findings were similar to those of Kumawat et al. [5].

Data revealed that there was no significant difference in the interaction effect of sequential intercropping systems and integrated nutrient management practices on grain, stalk and total nitrogen, phosphorous and potassium uptake during both the years of study.

4. CONCLUSION

Based on the data, it can be concluded that sole cropping of pigeonpea (S_1 and S_2) recorded maximum nutrient uptake and supplying nutrients through an integrated strategy (N_2) rather than fertilisers alone (N_1) increases nutrient availability and thus nutrient uptake.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Indiastat; 2019. Avaialble:https://www.indiastat.com/ agriculture–data/2/agricultural production /225/ stats.aspx.
2. Marer SB, Lingaraju BS, Shashidhara GB. Productivity and economics of maize and pigeonpea intercropping under rainfed condition in Northern Transitional zone of Karnataka. Karnataka Journal of Agricultural Sciences. 2007;20(1):1-3.
3. Kumar U, Kushwaha HS. Studies on nutrient management in pigeonpea [*Cajanus cajan* (L) Millsp.] based intercropping system of urd bean, sesame and mung bean. Journal of Pharmacognosy and Phytochemistry. 2018;7(2):490-494.
4. Patil AB, Padmani DR. Nutrient uptake pattern of pigeonpea (*Cajanus cajan*) as influenced by integrated nutrient management. International Journal of Agricultural Sciences. 2007;3(2):176-178.
5. Kumawat N, Singh RP, Kumar R. Effect of integrated nutrient management on productivity, nutrient uptake and economics of rainfed pigeonpea (Cajanus cajan) and black gram (*Vigna mungo*) intercropping system. Indian Journal of Agricultural Sciences. 2015; 85(2):171-176.
6. Jackson ML. Soil chemical analysis. Prontices hall of India, New Delhi; 1967.
7. Subbaiah BV, Asija G. A rapid procedure for estimation of available nitrogen in soil. Current Science. 1956;25:259-260.
8. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus by extraction with sodium bicarbonate. US Department of Agriculture, Circular. 1954; 939.
9. Jackson ML. Soil chemical Analysis. Prentice hall of India Private Limited. New Delhi. 1973;498.
10. Singh T, Pal M. Growth parameters, yield attributes and yield of pigeonpea as influenced by cropping system and nitrogen + phosphate levels. Annual Agricultural Research. 2003;24(4):755-759.
11. Arnon I. Crop production in dry region. In: N. Polwin (ed.) Background and principles. International textbook company limited, London. 1972;284.
12. Kumar A, Rana KS. Performance of pigeon pea (*Cajanus cajan* L.) + green gram (Vigna radiata) intercropping system as influenced by moisture-conservation practices and fertility level under rainfed conditions. Indian Journal of Agronomy. 2007;52(1):31–35.

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