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Yield and economic of pigeonpea (*Cajanus cajan* L. Mill sp.) intercropping system under Northern dry zone of Karnataka

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Abstract
Pigeonpea (*Cajanus cajan* L. *Mill sp.*) is grown in rainfed as well as dry region of India, growing of only pulses is not so much remunerative in present scenario of dry areas of agriculture to fulfill the diverse demand of consumers and rapid growing population. A field experiment was conducted during *Kharif* 2021 and 2022 and the experiment consisted of pigeonpea and six different nutria-rich millets *viz*., barnyard millet, Kodo millet, little millet, proso millet, brown top millet and teff. The maximum number of pods (156), number of seeds per pod (4.16) seed weight per plant (44.66 g plant^{-1}) and test weight (10.81g) were observed in sole pigeonpea, which was superior and at par with nutri-rich millet inter crop while lowest in pigeonpea + brown top millet.

Keywords: Yield, intercropping, teff and nutria-rich millets

Introduction
Pigeonpea, being an important nitrogen-fixing legume it enriches soil nutrient status and its deep root system help to bring nutrients and moisture from the deeper layer of the soil profile. The protein content of the crop varies from 20-21%, which made this an important protein diet for many people in the world. In traditional agriculture it is also called "biological plough" and "Kalpavriksha" of Rainfed areas because all the parts are beneficial in one or the other way, other benefits like food and dried branches can be used as fuel and thatching material and also for making baskets. Pigeon pea is a crop for rainfed environments endowed with several features to thrive harsh climate. It adapts well in sole crop and intercropped conditions (with cereals, millets, oils seeds and pulses) by enhancing the system productivity and net income to the small and marginal farmers across the globe. Millet cultivation is declining due to several reasons few of which are processing hardships, low economic gains and lack of awareness about the nutritional significance. The area under millets is declining at an alarming rate in spite of the favourable cultivation conditions available. This has adversely affected the nutritional security and agricultural cropping systems.

Materials and Methods
The field experiment was conducted during *kharif* season for two year (2021 and 2022) at ICAR- Krishi Vigyana Kendra, Vijayapura. It was laid out in RCBD with thirteen treatments and three replications. The treatments were T_1 = Pigeonpea (Sole), T_2 = Teff (Sole), T_3 = Barnyard millet (Sole), T_4 = Browntop millet (Sole), T_5 = Little millet (Sole), T_6 = Kodo millet (Sole), T_7 = Proso millet (Sole), T_8 = Pigeonpea + Teff (1:2), T_9 = Pigeonpea + Barnyard millet (1:2), T_{10} = Pigeonpea + Browntop millet (1:2), T_{11} = Pigeonpea + Little millet (1:2), T_{12} = Pigeonpea + Kodo mille (1:2), T_{13} = Pigeonpea + Proso millet (1:2).

Results and Discussion
In the present investigation, nutri - rich millets were intercropped with pigeon pea. Two rows of nutri - rich millets between a row of pigeonpea had significantly influenced pigeonpea performance.

The results showed pooled data revealed that sole pigeopea recorded significantly, higher number of pods per plant (156) and seed weight per plant (44.66 g) but it was found on par with pigeonpea + Teff (136 and 42.35 g, respectively), pigeonpea + barnyard millet (133 and 41.30 g, respectively) and pigeonpea + kodo millet (130 and 40.39 g, respectively). Significantly lower number of pods per plant (136 and 42.35 g, respectively) and seed weight per plant (136 and 42.35 g, respectively) was recorded under pigeonpea + browntop millet (120 and 37.67 g, respectively). (Table 1)

The data concerned to seed yield of pigeonpea are presented in Table 1. The results indicated that the seed yield of pigeonpea was significantly. Influenced due to different nutri – rich millets with 1:2 row proportion under intercropping. Pooled data indicated that significantly. Higher seed yield of pigeonpea was recorded under sole pigeonpea (1526 kg ha^{-1}) and it was found on par with pigeonpea + teff (1447 kg ha^{-1}) and pigeonpea + barnyard millet (1411 kg ha^{-1}). However, significantly. lower seed yield was noticed in intercropped treatments *viz*., pigeonpea + browntop millet (1287 kg ha^{-1}), pigeonpea + little millet (1312 kg ha^{-1}), pigeonpea + proso millet (1348 kg ha^{-1}) and pigeonpea + Kodo millet (1380 kg ha^{-1}) which were on par with each other. The yield components were directly responsible for higher seed yield and were known to have been determined by physiological characters both in the vegetative and reproductive phases of growth. Seed yield is the resultant product, which obviously depends upon the dry matter production at different stages of crop growth and its partitioning into reproductive parts at higher proportion. The photosynthetic ability of plant at various stages of crop growth can be assessed through leaf area and dry matter accumulation in leaves which in turn affects the photosynthetic ability of plant and to higher yield attributing characters *viz*., number of pods per plant, number of seeds per pod, seed weight per plant and test weight (Table 1) which were significantly. Higher in sole crop of pigeonpea as compared to intercropping. Similarly pigeonpea intercropped with greengram and cowpea in different row proportions produced lesser pigeonpea seed yield (Rana and Pal, 1997) [5]. Sole crops of maize and pigeonpea recorded significantly higher grain yield while the yield of the component crops were reduced significantly in the intercropping system as observed by Marer *et al*. (2005) [2]. Yield attributes and yield was reduced when pigeonpea was intercropped with sorghum (Pal *et al*., 2016) [3].

The net returns recorded under different treatments are presented in Table 2. The pooled data revealed that sole pigeonpea recorded significantly highest net returns (Rs.51857 ha^{-1}) over the sole crops of barnyard millet, browntop millet, little millet, kodo millet, proso millet and teff. Among the intercropped treatments, pigeonpea + teff (Rs.118188 ha^{-1}) was recorded significantly higher net returns over pigeonpea + browntop millet (Rs.47091 ha^{-1}).

The benefit cost ratio recorded under different treatments is presented in Table 2. The pooled data of 2021 and 2022 revealed that. Significantly higher benefit cost ratio was noticed in sole teff (2.71) over the intercropped treatments and sole crops of pigeonpea, barnyard millet, browntop millet, little millet, kodo millet and proso millet. Among the intercropped treatments Pigeonpea + teff (2.63) was recorded significantly higher benefit cost ratio than pigeonpea + browntop millet (2.04).

In present study, comparative economics of pigeonpea based intercropping systems revealed that higher seed yield with higher market price of pigeonpea and teff ensured the higher net returns under pigeonpea + teff intercropping systems over other intercropping systems. A similarly significantly higher net return was recorded in intercropping of pigeonpea with teff. Finally in terms of economic net returns pigeonpea + teff accrued benefits higher. Similar results of higher net returns were reported with pigeonpea based intercropping systems by Tiwari *et al*. (2016) [6] and Arjun Sharma and Guled (2012) [1]. With respect to B: C ratio, the significantly higher benefit cost ratio was recorded with pigeonpea + teff intercropping system. However significantly lower benefit cost ratio was recorded under sole browntop millet over their respective intercropping systems. The higher B:C ratio under pigeonpea + teff was due to higher market price of pigeonpea and teff when compared to other crops. Similar results were reported by Pawar *et al*. (2013) [4].

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Table 1: Number of pods per plant, number of seeds per pod, seed weight $plant^{-1}$ (g) and test weight (g) of pigeonpea as influenced by pigeonpea and nutri - rich millets intercropping system

Treatments	Number of pods per plant			Number of seeds per pod			Seed weight $plant^{-1}$ (g)			Test weight (g)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1. Pigeonpea (Sole)	158	154	156	4.17	4.15	4.16	45.92	43.41	44.66	10.84	10.78	10.81
T_2. Teff (Sole)	-	-	-	-	-	-	-	-	-	-	-	-
T_3. Barnyard millet (Sole)	-	-	-	-	-	-	-	-	-	-	-	-
T_4. Browntop millet (Sole)	-	-	-	-	-	-	-	-	-	-	-	-
T_5. Little millet (Sole)	-	-	-	-	-	-	-	-	-	-	-	-
T_6. Kodo millet (Sole)	-	-	-	-	-	-	-	-	-	-	-	-
T_7. Proso millet (Sole)	-	-	-	-	-	-	-	-	-	-	-	-
T_8. Pigeonpea + Teff (1:2)	138	134	136	4.15	4.13	4.14	42.50	42.18	42.35	10.72	10.64	10.68
T_9. Pigeonpea + Barnyard millet (1:2)	134	131	133	4.14	4.11	4.13	41.68	40.89	41.30	10.65	10.58	10.61
T_{10}. Pigeonpea + Browntop millet (1:2)	121	119	120	3.90	3.87	3.89	38.75	36.59	37.67	10.47	10.45	10.46
T_{11}. Pigeonpea + Little millet (1:2)	123	122	123	3.98	3.91	3.95	39.28	37.49	38.40	10.55	10.48	10.51
T_{12}. Pigeonpea + Kodo mille (1:2)	131	129	130	4.08	4.01	4.05	41.06	39.69	40.39	10.61	10.55	10.58
T_{13}. Pigeonpea + Proso millet (1:2)	127	124	126	4.02	3.97	4.00	40.27	38.61	39.45	10.58	10.51	10.54
S.Em±	10	8	9	0.17	0.13	0.21	1.42	1.19	1.11	0.01	0.03	0.01
C.D (P=0.05)	30	24	27	NS	NS	NS	4.29	3.61	3.37	NS	NS	NS

Table 2: Seed yield (kg ha^{-1}), net returns (Rs. ha^{-1}) and benefit cost ratio as influenced by pigeonpea and nutri - rich millets intercropping system

		Seed yield (kg ha^{-1})			Net returns (Rs. ha^{-1})			Benefit cost ratio		
Tr. No.	**Treatment detail**	**2021**	**2021**	**pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_1	Pigeonpea (Sole)	1569	1483	1526	53855	49858	51857	2.45	2.27	2.36
T_2	Teff (Sole)	-	-	-	35656	31156	33406	2.88	2.55	2.71
T_3	Barnyard millet (Sole)	-	-	-	16235	16292	16264	1.83	1.78	1.81
T_4	Browntop millet (Sole)	-	-	-	9523	9726	9625	1.49	1.47	1.48
T_5	Little millet (Sole)	-	-	-	16290	16543	16417	1.84	1.81	1.82
T_6	Kodo millet (Sole)	-	-	-	10783	11026	10905	1.55	1.53	1.54
T_7	Proso millet (Sole)	-	-	-	11886	11963	11925	1.61	1.58	1.59
T_8	Pigeonpea + Teff (1:2)	1452	1441	1447	73997	72494	73246	2.69	2.57	2.63
T_9	Pigeonpea + Barnyard millet (1:2)	1424	1397	1411	60861	59861	60361	2.38	2.28	2.33
T_{10}	Pigeonpea + Browntop millet (1:2)	1324	1250	1287	48878	45304	47091	2.11	1.97	2.04
T_{11}	Pigeonpea + Little millet (1:2)	1342	1281	1312	54831	52217	53524	2.25	2.12	2.18
T_{12}	Pigeonpea + Kodo millet (1:2)	1403	1356	1380	55449	53784	54617	2.26	2.15	2.20
T_{13}	Pigeonpea + Proso millet (1:2)	1376	1319	1348	54154	51405	52780	2.23	2.10	2.16
	S.Em±	49	37	41	2298	2930	1880	0.07	0.04	0.09
	C.D(P=0.05)	148	114	124	6891	8791	5639	0.21	0.14	0.29

Conclusion

Based on two year results, it may be summarized that significantly higher pigeon pea yield and benefit cost ratio was recorded with intercropping system compared to their sole cropping. The results indicated that, growing of pigeon pea with nutri - rich millet at 1:2 row proportions recorded higher pigeon pea yield and benefit cost ratio as compared to other sole cropping systems and more remunerative over sole cropping. Therefore, it was concluded that pigeon pea + teff (1:2) intercropping system was found suitable for Northern Dry Zone of Karnataka under rainfed condition.

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