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Utilization of waste cultivable upland through Intercropping of fodder with Pigeon Pea (*Cajanus cajan*): Multi remedial approaches in agricultural system of Jharkhand

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Abstract
A field experiment was conducted under All India Coordinated Research Project on (Forage Crops & Utilization) with the collaboration of Agrostology unit of College of Veterinary Science and Animal Husbandry Ranchi (Jharkhand) to study the Suitability of different cereal and legume fodder as intercropped with Pigeon pea (*Cajanus cajan*) during three consecutive *Kharif* seasons from 2014 to 2016. *Kharif* fodders as Sorghum, Maize, Pearl millet, Soybean, Rice bean, Cowpea and Clustered bean were intercropped in between two paired row 60 cm apart of Pigeon pea (paired at 30 cm). Altogether eight treatments were replicated thrice and analyzed the results. Pooled data of three years showed that, more pigeon pea yield (10.058 q/ha) was obtained when pigeon pea intercropped with Soybean and which was about more than 4.5% than sole Pigeon pea (9.62 q/ha). However, intercropped Sorghum produced more green fodder yield (174.45 q/ha) and dry fodder yield (37.145 q/ha) as well as Land equivalent yield (LER) 1.527. While, productivity per day were maximum with fodder maize (2.56 q/ha/day as green) and (0.56 q/ha/day as dry). In System, Pigeon pea + Cowpea intercropping system produced more Pigeon pea yield equivalent (15.76 q/ha) which was nearly 64% more than sole Pigeon pea. In other word, yield advantage due to paired row intercropped with fodder Cowpea showed 64% yield advantages over sole.

Keywords: pigeon pea, sorghum, maize, pearl millet, soybean, rice bean, cowpea, clustered bean, intercropped, yield advantages, land equivalent ratio and paired row

Introduction
Newly separated state Jharkhand is Middle to Southern part of undivided Bihar, which comes into existence during November 2000. At present it comprises total 24 districts, which comes under Agro climatic sub division IV, V and VI. Land of this state is undulating, platue, plain and red laterite soil *ie Alfisol* is major class of soil. Jharkhand is a state where 80 percent of the farmers come under marginal category with holding size less than 2.5 Acre of land. That's why they do not prefer fodder in good land, so scope of fodder cultivation shifted towards waste and or un-cultivated upland. Topographically entire land of Jharkhand is divided into three categories, out of which 40% comes under upland categories and 45-50% of said upland are always fallow even during *Kharif* due to fertility and topographic problem. This patch of land can be an effective resource for cultivation of fodder and pulses crop to cope up the shortage of animal green feed. These lands are generally characterized by less organic matter content with low water holding capacity as well as poor fertility coupled with compactness which results into more expense of money and energy during cultivation of cereal and vegetable crops.

Cultivation under said land with pulses/ legumes not only improves the soil heath, but also improves the productivity of animal and human too. Growing legumes and cereals together for food and fodder production is not only popular among subsistence farmers in the world, but it is demand of the day throughout the India as well as Jharkhand too. The benefits of inter-cropping system generally realized in areas where the rainy season is long and favorable enough to grow more than one crop of different duration simultaneously or successively, or where irrigation is available (Mandal *et al*. 1990) [7]. Apart from the cereal and legumes for human being, fodder cultivation attracts the farmers to domesticate the lactating animals, which certainly improves their Socio- economic condition.

In present contest protein became the essential parts of ration of human as well as animal which can be made available from pulses for human and green fodder for animals. Among the legume Pigeon pea being deep rooted and best human protein and fodder Cowpea, Rice bean, fodder Soybean and Cluster bean are suitable for intercropped as well as sole cropping. Besides it the importance of cereal fodder likes Sorghum, Maize and Pearl millet can't be ignored which acts as body building feed and sources of roughs too. Thus, in order to minimize the hidden hungriness and too cope up from malnutrition among three dimensional agricultural systems that is Soil, Animal and human growing of fodder along with Pulses in particular piece of land simultaneously is demand of the time. Apart from the above facts, to increase the area under cultivated land, and too increase cropping intensity, deep rooted legumes along with fodder as intercrop must be taken during the *Kharif* which will help in nutritional security of our system. Keeping the above facts in view present experiments was conducted on "Utilization of waste cultivable upland through Intercropping of fodder with Pigeon Pea (*Cajanus cajan*) as three dimensional remedy in Agricultural system of Jharkhand".

Materials and Methods

A Field experiment was conducted during three consecutive *Kharif* season from 2014 to 2016 under All India Coordinated Project on Forage Crops at BAU, Ranchi situated at 23º.34' N latitude and 85º.31' E longitudes at an altitude of 645.45 meter above the mean sea level. It falls under humid sub tropical climatic conditions, which have features of hot dry summers and cool dry winters. The soil of the experimental field was sandy loam in texture, slightly acidic in reaction having different physical and chemical properties mentioned here under (Table 1). The experiment was laid out in Randomized Block Design (RBD) with eight treatments namely, T1 – Sole Pigeon pea (at R-R,60 cm), T2 – Pigeon pea + Sorghum (2:1), T3 – Pigeon pea + Maize (2:1), T4 – Pigeon pea + Pearl millate (2:1), T5 – Pigeon pea + Soyabean (2:1), T6 – Pigeon pea + Rice bean (2:1), T7 – Pigeon pea + Cowpea (2:1) and T8 – Pigeon pea + Clusture bean. Above treatment were sown in plot size 4 m x 3 m and replicated thrice. Initialy well decomposed Farm Yard Mannure @10 tons/ha were applied.

Table 1: Physiochemical properties of the soil of experiment plot.

Sl. No	Particulars	Value	Method used
I	Physical properties		
1.	Sand (%)	61.2	Hydrometer method [1]
2.	Silt (%)	22.4	
3.	Clay (%)	16.4	
	Texture	Sandy loam	
II	Soil Moisture Constants		
1.	Water holding capacity (%)	41.3	Keen Raczki modified [12]
2.	Field capacity at 0.33 bar (%)	19.7	pressure membrane plate apparatus [6]
3.	Permanent wilting point at 15 bar (%)	11.36	pressure membrane plate apparatus [6]
4.	Bulk density (Mgm^{-3})	1.57	Core sampler [8] as described in [12]
III	Chemical properties		
1.	Soil pH (1:2.5, soil: water ratio)	6.23	Glass electrode pH meter [4]
2.	Organic Carbon (g/kg)	3.97	[15] as described in [14]
3.	Available N (kg/ha)	245	Alkaline $KMnO_4$ [13]
4.	Available P_2O_5 (kg/ha)	24.8	Colorimetric estimation [2]
5.	Available K_2O (kg/ha)	176	Flame Photometer [4]

Lines were oppened along the 3 m width at 30 cm aparts and two lines of Pigeon Pea and then one line of fodder as intercropped were sown. Under each plot 4 rows of fodder crop and 6 rows of Pigeonpea were sown at the same time, after harvest of fodder Pigeonpea get better space. Intercropped plots were sown with utilizing the exact proportionate amount of Inputs (Table-3). Full dose of N, P and K in Legumes were applied at the time of sowing, while Full dose of P K and halp dose of N in cereal at sowing time and rest halp dose of N applied after 25 DAS. Fertilizers were applied as per recomendation and crops not irrigated as it sown under rainfed condition.

Table 2: Crop wise details of Inputs standered rate and needed amount.

Sl. No	Crops	Cultivar	Seed Rate (Kg/ha)	RDF (Kg/ha)	Actual Needed Seed (Kg/ha)	Actual Needed N:P:K (Kg/ha)
1.	Pigeon pea	Asha	15	20: 50: 25	18	24:60:30
2.	Sorghum	SSG	20	60: 50: 25	8	24:20:10
3.	Maize	African tall	40	60: 50: 25	15	24:20:10
4.	Pearlmillet	NDFB-2	15	60: 50: 25	6	24:20:10
5.	Soyabean	Birsa Bold	50	20: 50: 25	20	8:20:10
6.	Rice bean	Bidhan -2	25	20: 50: 25	10	8:20:10
7.	Cowpea	Bundel lobia	25	20: 50: 25	10	8:20:10
8.	Clusture bean	Bundel Guar-1	25	20: 50: 25	10	8:20:10

Table 3: Treatment wise details of Inputs required.

Sl, No	Treatments	Seed Required (Kg/ha)	N:P_2O_5:K_2O (Kg/ha)
1.	T1- Sole Pigeonpea (at 60 cm R-R)	15	20: 50: 25
2.	T2 – Pigeon pea + Sorghum (2:1)	18 + 8	48: 80: 40
3.	T3 – Pigeon pea + Maize (2:1)	18 + 15	48: 80: 40
4.	T4 – Pigeon pea + Pearlmillet (2:1)	18 + 6	48: 80: 40
5.	T5 – Pigeon pea + Soyabean (2:1)	18 + 20	32: 80: 40
6.	T6 – Pigeon pea + Ricebean (2:1)	18 + 10	32: 80: 40
7.	T7 – Pigeon pea + Cowpea (2:1)	18 + 10	32: 80: 40
8.	T8 – Pigeon pea + Clusturebean (2:1)	18 + 10	32: 80: 40

Weather information: Average weather data of three crop years from standard meteorological week 23 to 10, *w.r.t.* Average humidity (%), Rain fall (mm), Sun shine hour, Temperature Maximum and Minimum (^{0} C) were recorded owing to the standard procedure and technique. Data are represented through graphical representation depicted in Figure 1. Graph reflects that crop faces the average humidity (max 83.83 & min 63.34%), Rain fall 35.07 mm /week, Sun Shine hour (50.94 hrs /week), Maximum temperature (38.3^0 C) and minimum temperature (3.5^0 C). Crops face slightly warmer at day and colder during night especially during winter season which causes less flowering as well as less pod formation in Pigeon pea.

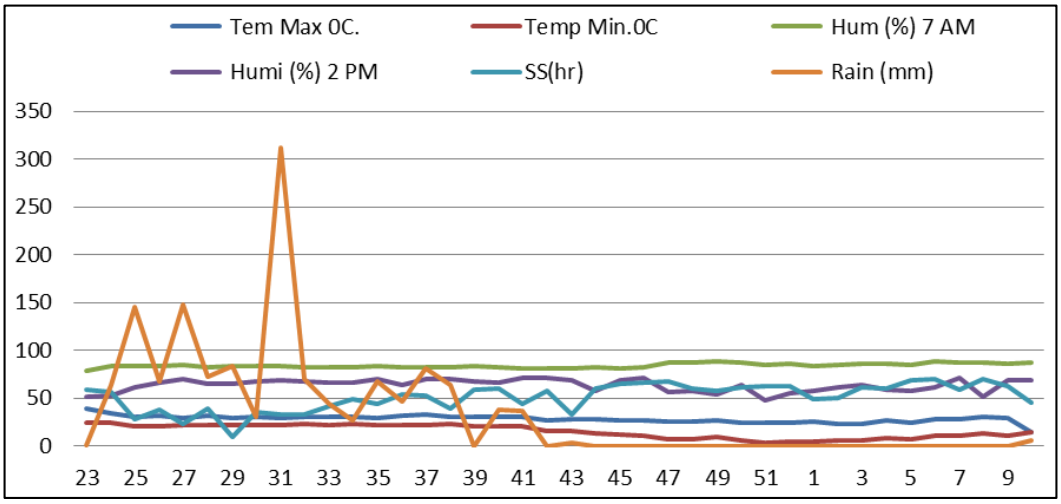

Fig 1: Average weekly weather data during crop period

Fodder were harvested at proper stage for difrent crops data of represented sample were taken from randomly selected place. Data were analyzed follow the standered formulla prescribed by Cochran, W.G. and Cox, G.M. 1957 [3].

Result and Discussion

Pigeon pea study: Plant height of sole Pigeon pea (178 cm) was significantly superior over when intercropped with cereal fodder like Pearl millet (168 cm), Maize (169 cm) while it was at par when intercropped with Sorghum (175 cm). Further maximum plant height of Pigeon pea was recorded when intercropped with Rice bean (190 cm) besides it with other legumes inters cropped plant height was at par (Table 4). Intercropping of legumes fodder improve the soil condition and add nitrogen as well as enhance availability of nutrients resulted into bigger plant height of main crop (Pigeon pea).

Pooled data showed that, the maximum grain yield of Pigeon pea was recorded under intercropped with Soya bean (10.058 q/ha), which was about 4.55% more than sole Pigeon pea yield (9.620 q/ha). This is due to better growth of Pigeon pea under intercropped than sole.

In terms of Pigeon pea equivalent yield, fodder cowpea intercropped with Pigeon pea produced more yield equivalent (15.76 q/ha) over sole Pigeon pea (9.620 q/ha) that is in other word cowpea intercropped with Pigeon pea produced about 63.82% more produced over sole Pigeon pea. This was due to combined effect of more plant population as well as well better growth due to better availability of nutrients. Natrajan and Willey (1980) [8] reported that, the intercropped combination of early sorghum (82 days) and later maturing pigeon pea (173 days) in a row arrangement of 2 sorghum:1 pigeon pea. Prior to sorghum harvest, light interception by the intercrop combination was almost as high as sole sorghum. After sorghum harvest, light interception by the remaining pigeon pea was very poor and it is suggested that pigeon pea yield could be increased by higher plant population density and better plant distribution. Soil water measurements indicated that this would increase the amount of water being transpired through the crop but would not increase the total evapo-transpiration demand. Higher nutrient concentration in the intercrop pigeon pea compared with sole pigeon pea during this post-sorghum period suggested that yield of intercrop pigeon pea was not limited by nutrient stress, though the total uptake of nutrients by both crops was much greater from intercropping than sole cropping.

Table 4: Plant height, yield and Pigeon pea yield equivalent of Pigeon pea under pigeon pea + fodder inter cropping system (Pooled).

Treatments	Pigeon pea study		Pigeon pea equivalent yield (q/ha)	Land equivalent ratio (LER)
	Plant height (cm)	Pigeon pea yield (q/ha)		
T1- Sole Pigeonpea (at 60 cm R-R)	178	9.620	9.620	1.00
T2 – Pigeon pea + Sorghum (2:1)	175	8.769	15.75	1.527
T3 – Pigeon pea + Maize (2:1)	169	8.795	15.71	1.524
T4 – Pigeon pea + Pearlmillet (2:1)	168	9.621	14.89	1.352
T5 – Pigeon pea + Soyabean (2:1)	182	10.058	13.24	1.289
T6 – Pigeon pea + Ricebean (2:1)	190	10.006	14.88	1.449
T7 – Pigeon pea + Cowpea (2:1)	184	10.044	15.76	1.518
T8 – Pigeon pea + Clusturebean (2:1)	185	10.053	13.67	1.333
S. Em ±	3.75	0.209	0.24	0.017
CD at 5%	8.26	0.461	0.53	0.052
CV%	2.57	2.67	2.04	2.12

Land equivalent ratio (LER) of treatment Pigeon pea+ Sorghum (1.527) Pigeon pea + Maize (1.524) and Pigeon pea + Cowpea (1.518) were maximum and at par to each other while, minimum were recorded under Pigeon pea+ Soybean (1.289). This was due to less Green fodder yield of Soybean compared to cereal fodder crops yield, which reflects into different Pigeon pea equivalent yield. Sarkar and Shit (1990) [11] and Quiroz and Marin (2003) [10] recorded higher LER and ATER in maize based intercropping system compared to sole cropping.

Fodder study: Three years pooled data of plant height/ vine length of diffrent fodder showed that, Sorghum attain more height (283 cm) over other fodder crops, while minimum was recorded under Soybean (89 cm). Intercropped Sorghum produced more green fodder yield (174.45 q/ha) and Dry fodder yield (37.145 q/ha), which were significantly higher over other fodder crops taken under experinmentation (Table 5).

Table 5: Plant height, Leaf: stem ratio, Yield and productivity per day of fodder crops under pigeon pea+ fodder inter cropping system (Pooled).

Treatments	Fodder study					
	Plant height(cm)	L:s ratio	GFY (q/ha)	GFY /day (q/ha/day)	DFY (q/ha)	DFY/day (q/ha/day)
T1	----	----	---	---	---	---
T2	283	0.352	174.45	1.54	37.145	0.33
T3	246	0.284	153.73	2.56	33.910	0.56
T4	256	0.362	131.69	2.09	24.543	0.39
T5	89	0.862	57.90	1.04	10.901	0.19
T6	185	1.075	88.62	1.41	17.735	0.28
T7	204	0.960	103.96	1.65	19.881	0.32
T8	128	0.992	65.74	1.04	10.712	0.17
S. Em ±	3.56	0.059	2.28	0.03	0.565	0.01
CD at 5%	7.83	0.130	5.02	0.07	1.244	0.02
CV%	2.19	10.38	2.52	2.65	3.13	3.45

The higher biomass production is frequently due to the enhanced growth of the component non-legume. Because the non-legume is generally taller than the legume and can therefore intercept adequate solar radiation, biomass production of the non-legume is more closely related to improved N nutrition (Rerkasem and Rerkasem 1988) [5].
In other hand, fodder productivity per unit time, fodder Maize produced green fodder (2.565 q/ha/day) and dry fodder (0.56 q/ha/day) which were more over other, while lowest productivity/day were recorded under fodder Soybean.

Soil health: After every year experinmentaion Mung were uniformly taken at RDF (20:50:20) for renovation of soil and further after three years of experinmentation soil health improvment takes place with Soil organic carbon (4.01 g/kg), pH 6.27, available N (278 kg/ha), Available P_2O_5 (32.8 Kg/ha)and Available K_2O (184 Kg/ha).

Summery and conclusion
Pigeon pea (Asha) with less branching ability was taken in paired row at 30 cm. One row of different fodder crops were placed in between the distance of 60 cm. paired to pair. As intercrop sorghum or maize among the cereal and rice bean among the legume performed equally well. However, Higher yield of Pigeon pea (10.058 q/ha) was recorded when intercropped with Soybean, and higher green fodder yield (GFY, 174.45 q/ha), DFY, 37.145 q/ha) from intercropped Sorghum while, productivity /day *i.e* GFY/ha/day (2.56 q/ha/day) and DFY/ha/day (0.56 q/ha/day) can be taken from maize intercropped with Pigeon pea. Total Pigeon pea yield equivalent (15.71 q/ha) can be easily obtained, when crops were fertilized with standered recommended dose of fertilizer. However, in terms of system Pigeon pea yield equivalent; Fodder cowpea when intercropped with Pigeon pea produced maximum 15.76 q/ha which was about 64% more than sole Pigeon pea. In nutshell, through intercropping of Pigeonpea and fodder certainly improve the soil health and will produced good remuneration through Production of pulses for human as well as fodder for animal.

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