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Performance of Arhar - based little millet intercropping under rain-fed conditions of Odisha

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Abstract
The field experiment was carried out at Regional Research and Technology Transfer Station (OUAT), Semiliguda, Koraput under Eastern Ghat High Land zone of Odisha, India during *kharif* 2019 and 2020. The objective of the study was to identify the suitable planting pattern and fertilizer dose in itercropping system arhar+liitle millet. The experiment comprised of nine treatments and laid out in factorial randomized block design (FRBD) with replicated thrice consisting Factor-I (3 planting pattern) *viz*; arhar+little millet (1:1), arhar+little millet (2:2), arhar+little millet (1:2) and Factor –II (3 Fertilizer dose) *viz*. 100% soil test based fertilizer (STBF) to Arhar+0% recommended dose (RD) to little millets, 100% STBF to Arhar+50% RD to little millets, 100% STBF to Arhar+100% RD to little millets. Little millet variety "OLM 203" and arhar variety "BRG-5" were sown at recommended dose of fertilizer 40-20-20 NPK kg/ha for little millet and 20-40-40 NPK kg/ha. Among the different treatment imposed to base crop, the highest yield of arhar (1043.5) kg/ha was recorded in the planting pattern P2 (2:2) and seed yield 1045.3 kg/ha in the fertilizer dose M3(100% STBF to Arhar+100% RD to little millet). Where as in intercrop the highest yield of little millet in Planting pattern of P3 (1:2) ratio produced significantly higher yield 389 kg/ha accounting 3.5% and 8.5% higher yield, over P2 and P1. The yield of little millet 445.3 kg/ha recorded under fertilizer dose M3 (100% STBF to arhar + 100% STBF to little millet) was significantly superior, registering 17.85% higher yield than M2 and 30.68% higher than M1.

Keywords: Planting pattern, intercropping, Arhar Equivalent Yield (AEY), B:C ratio

Introduction
Arhar (*Cajanus cajan* L.) also known as tur, pigeon pea or red gram is one of the most important *kharif* pulse crop cultivated both as sole crop and as an intercrop in India. For small and marginal farmer in rainfed areas, it is a most important crop for livelihood. In India it occupies 2nd position after chick pea in terms of area and production among the pulses. However, Arhar grown as sole crop shows less economically viable, because of its slow initial growth rate, wide inter-row space, high weed infestation and longer crop duration (Sathiya *et al.*, 2025) [12]. So short duration crop like little millets can be incorporated in the inter-row space through inter cropping to make the pigeon pea more economical viable and sustainable.

Millet and pulse intercropping isn't merely a combination of two crop-it's a synergistic partnership that enriches the soil, empowers farmers, and ensures food and nutritional security (Kumar and Ray 2020) [7]. Beyond increasing yields; it's creates an ecological balance that sustain life-from the soil microbes to the pollinator and birds. Intercropping, the age-old practice is rooted in the wisdom of our ancestors has gained renewed relevance in the modern context of climate change, land degradation and nutritional insecurity.

Pulses, as natural nitrogen-fixers, capture atmospheric nitrogen and convert it in the plant available forms, thereby reducing the need for synthetic fertilizers and improving soil health (Srilakshmi *et al.*, 2020) [16]. Crop diversification through intercropping is also essential to get higher yield stability, maintain soil fertility, conserving natural resources, preserving environment, meeting food and fodder requirement, reducing risk from price fluctuation and ensure constant flow of income to farmers (Sivagamy *et al.*, 2024) [14] In Southern parts of Odisha, a range of millets- particularly finger millet, little millet, foxtail millet, brown top millet and kodo millet are cultivated under diverse land situation and socio economic conditions.

However most of the farmer grows theses crops as a mono-cropping resulting nutrient imbalance, reducing yield and lower farm income. Thus, there is an urgent need to identify suitable arhar-based intercroping system for the Eastern Ghat High Land (EGHL) zone of Odisha to enhance productivity, sustainability, and profitability for smallholder farmers.

Materials and Methods

The field experiment was conducted at Regional Research and Technology Transfer Station (OUAT), Semiliguda, Koraput under Eastern Ghat High Land zone of Odisha during *kharif* seasons of 2019 & 2020. The farm is located in the geographical parallels of $18^0$42'N latitude, $82^0$30'E longitude and an altitude of 884 meter above mean sea level. The region is marked by its wet and humid climate with an average annual rainfall of 1521 mm most of which is received from mid-June to mid-October. The soil of experimental site was characterized as sandy loam in texture with pH 3.9 (acidic), low in both organic carbon (0.11%) & N (248 kg/ha) and high in both P (48 kg/ha) & K (519 kg/ha). The experiment was laid out in Factorial Randomized block design with three replications consisting Factor-I (3 planting pattern) *viz*; arhar+little millet (1:1), arhar+little millet (2:2), arhar+little millet (1:2) and Factor –II (3 Fertilizer dose) *viz*. 100% Soil test based fertilizer (STBF) to Arhar+0% recommended dose (RD) to little millets, 100% STBF to Arhar+50% RD to little millets, 100% STBF to Arhar+100% RD to little millets. Little millet variety "OLM 203" and arhar variety "BRG-5" were sown at recommended dose of fertilizer 40-20-20 N P K kg/ha for little millet and 20-40-40 N, P, K kg/ha. The growth and yield parameter of each crop was recorded by taking 5 plant in each treatment to calculate the average. Arhar equivalent yield (AEY) of inter cropping system in different spatial ratio was calculated by taking into account the seed yield and the prevailing market price of both the crops. AEY was calculated as

$$\text{AEY(kg/ha)}=\frac{\text{Yield of little millet}\left(\frac{kg}{ha}\right)\times\text{Price of little millet}\left(\frac{Rs}{kg}\right)}{\text{Price of Arhar}\left(\frac{Rs}{kg}\right)}+\text{Yield of arhar}\left(\frac{Kg}{ha}\right)$$

Cost of cultivation of arhar and little millet was working out based on prevailing market prices of the inputs. Gross returns were calculated using the pooled pigeon pea equivalent yield (kg/ ha) were taken into account. The net returns per hectare was calculated by deducting the cost of cultivation from gross returns per hectare. The benefit cost ratio was calculated as follows.

$$\text{Benefit cost ratio}=\frac{\text{Gross return}\left(\frac{Rs}{ha}\right)}{\text{Cost of cultivation}\left(\frac{Rs}{ha}\right)}$$

The data collected were subjected to statistical analyses by using ANOVA in the factorial randomized complete block design following the method of Gomez and Gomez (1984) [3]. Critical difference was worked out at 5% probability level whether the treatment was significant.

Results and Discussion

Intercropping legumes and cereals can increase agricultural productivity and reduce the inputs of nitrogenous fertilizer, which has been confirmed by many studies (Ram and Meena *et al.*, 2014) [11]. Plant height, no of branches per plant of arhar were significantly influenced by different planting pattern and fertilizer dose. In the intercropping system, little millet, being a short-duration crop, matured and was harvested earlier than the base crop arhar. This early harvest created favorable conditions for arhar, allowing it to utilize more resources such as light, space, and nutrients, thereby enhancing its growth and yield parameters.

Arhar

Effect of planting pattern

Two year pooled mean data revealed that, different planting pattern significantly influence the plant height, number of branches/plant, number of pods/plant, pod length and yield of arhar except number of seeds/pod and 100 seed weight (Table-1). Planting of arhar+little millet (2:2) ratio recorded significantly higher growth parameters *viz*. plant height (196.5), number of branches/plant (10.2), similarly in case of yield parameters highest number of pods/plant (157.3), pod length (4.4) was recorded in (2:2) ratio of planting of arhar+little millet. The higher yield of 1043.5 kg/ha obtained from arhar+little millet (2:2) ratio planting and it was 13.96% higher than (1:2) ratio and at par with (1:1) ratio of planting. The highest yield might be due to growth and yield attributes characters and space obtained after the harvest early variety of little millets. This favour for development of better complementary relationship and non-renewable resources like water, nutrients and incoming solar radiation. This finding is corroborated with the findings of Maini *et al.*, (2022) [8] and Kiranmani *et al.*, (2021) [6].

Effect of Fertilizer dose

With respect to fertilizer dose, the study revealed that balanced fertilization and integrated nutrient application significantly enhanced seed yield. Further, intercropping with little millet had positively influenced the yield of arhar, as little millet is a short-duration crop with minimal canopy cover. Hence, it less competitive for resources. This advantage was clearly reflected in the growth and yield parameters of arhar.

From the two year pooled data revealed (Table-1) that fertilizer applied in the treatment M3 (100% STBF to Arhar+100% RD to little millet) recorded higher number growth and yield parameters of arhar, which was superior to other two treatments. The seed yield 1045.3 kg/ha in the treatment M3 (100% STBF to Arhar+100% RD to little millet) produced 8.38% and 8.16% more than M2 and M1 respectively. This could be attributed to the fact that little millet did not compete with arhar for resources such as nutrients, solar radiation and moisture because of its shorter duration. Moreover, the residual effect of nutrient applied to little millet might have been absorbed by arhar as it is a deep-rooted crop. The improvement of yield of pigeon pea have been reported by Aliveni *et al.*, (2025) [1] and Dewangan *et al.*, (2025) [2].

Interaction effect between planting pattern × fertilizer dose (Table-1) was found to be significant with respect to number of braches/plant and seed yield. The result indicated that planting of arhar+littlemillet (2:2) with application of M3(100% STBF to Arhar+100% RD to little millet) recorded significantly higher arhar seed yield 1115 kg/ha compared to other except P1M1, P1M3, P2M2 and all are superior over other treatment combinations.

Table 1: Influence of planting pattern and nutrient management on growth and yield parameter of Arhar (main/base crop) (Two year pooled data)

Treatment	Plant height (cm)	Number of branches/plant	Number of pod/plant	Pod length (cm)	Number of seeds/pod	100 seed weight (g)	Yield (kg/ha)
Planting pattern (Arhar + Little millet)							
P1 (1:1)	192.9	9.2	145.3	4.3	4.1	8.2	1021.7
P2 (2:2)	196.5	10.2	157.3	4.4	4.1	8.4	1043.5
P3 (1:2)	188.0	9.8	149.4	4.2	4.1	8.3	897.8
S.Em (±)	1.7	0.1	2.9	0.1	0.0	0.1	24.5
CD (0.05)	5.1	0.4	8.8	0.2	NS	NS	73.4
Fertilizer dose							
M1	193.3	8.1	138.0	4.1	4.0	8.0	960.0
M2	189.6	9.3	146.7	4.3	4.1	8.3	957.7
M3	194.4	11.7	167.3	4.4	4.2	8.5	1045.3
S.Em (±)	1.7	0.1	2.9	0.1	0.0	0.1	24.5
CD (0.05)	5.1	0.4	8.8	0.2	0.1	0.3	73.4
Inreraction (P×M)							
S.Em (±)	2.9	0.2	5.1	0.1	0.1	0.2	42.4
CD (0.05)	NS	0.6	NS	NS	NS	NS	127.2

N.B.- P1(1:1) arhar + little millet, P2 (2:2) arhar + little millet, P3 (1:2) arhar + little millet, M1: (100% STBF to Arhar+0% RD to little millet), M2: 100% STBF to Arhar+50% RD to little millet), M3: (100% STBF to Arhar+100% RD to little millet).

Little millet

Effect of planting pattern

Planting pattern significantly influenced the yield attributing parameters like number of tillers/plant, panicle length and yield except secondary tillers/plant (Table-2). Planting of P3 (1:2) ratio produced significantly higher yield 389 kg/ha accounting 3.5% and 8.5% higher yield, over P2 and P1 respectively. This could be due to higher plant population as compared to other intercropping row ratio. This results are in conformity with the findings of Sharmili and Parasuraman (2018) [13] and Prasannasreenithi *et al.*, (2023) [10]

Effect of Fertilizer dose.

Different dose of fertilizer application (Table-2) significantly improved yield parameters of inter crop little millets. Application of 100% STBF to Arhar+100% to little millet (M3) produced higher number of tiller/plant (4.4), secondary tiller/plant (4.7), panicle length (35.2) and yield 445.3 kg/ha. The yield recorded under M3 (100% STBF to Arhar+100% to little millet) was significantly superior, i.e. 17.85% more than M2 and 30.68% more than M1. This higher yield can be due to better growth and yield parameters, which facilitated efficient nutrient uptake, adequate accumulation of photosynthates and consequent enhancement of yield attributing parameters leading to higher yield. Similar findings were reported by Math *et al.*, (2020) [9] and Dewangan *et al.*, (2025) [2].

The interaction effect of Planting pattern × Fertilizer dose (Table-2) was found to be non significant.

Table 2: Influence of planting pattern and nutrient management on growth and yield parameter of intercrop little millet (Two year pooled data)

Treatment	Plant height (cm)	Number of tiller	Secondary tiller	Panicle length (cm)	Yield (kg/ha)
Planting pattern (Arhar + Little millet)					
P1 (1:1)	142.7	3.8	4.6	30.6	356.0
P2 (2:2)	142.1	4.0	4.5	32.2	375.1
P3 (1:2)	141.5	4.1	4.6	33.3	389.0
S.Em (±)	1.7	0.0	0.1	0.7	5.8
CD (0.05)	NS	0.1	NS	2.0	17.5
Fertilizer dose					
M1	136.6	3.6	4.4	28.8	309.0
M2	143.6	3.9	4.5	32.2	365.8
M3	146.1	4.4	4.7	35.2	445.3
S.Em (±)	1.7	0.0	0.1	0.7	5.8
CD (0.05)	5.1	0.1	0.2	2.0	17.5
Interaction (P×M)					
S.Em (±)	3.0	0.1	0.1	1.2	10.1
CD (0.05)	NS	NS	NS	NS	NS

N.B.- P1(1:1) arhar + little millet, P2 (2:2) arhar + little millet, P3 (1:2) arhar + little millet, M1: (100% STBF to Arhar+0% RD to little millet), M2: 100% STBF to Arhar+50% RD to little millet), M3: (100% STBF to Arhar+100% RD to little millet).

Yield advantage indices

Arhar grain equivalent yield (AEY)

One of the most important indicator in intercropping system is crop equivalent yield (CEY). Crop Equivalent Yield (CEY) converts the yields of various intercrops or crops into an equivalent yield of a standard crop based on market prices, enabling better economic comparison. Arhar equivalent was calculated for better comparison of inter cropping system. Arhar seed equivalent yield (AEY) of planting pattern and fertilizer is presented in (Table -3) showed that P2 (2:2) recorded significantly higher AEY (1255 kg/ha) which was at par with P1 (1:1) 1223 kg/ha and differ from P3 (1:2) 1117 kg/ha. The increase in pigeonpea equivalent yield in pigeonpea + little millet (2:2) intercropping system might be due to no or low competition between main crop and intercrop for growth, development and for above ground and below ground resources and the complementary utilization of resources (Kathmale *et al.*, 2014) [4]. Similar finding was reported by Sivagamy *et al.*,

(2020) [14] and Vadhani *et al*., (2025) [18]. Kiranmai *et al*., (2021) [6] also report in Foxtail millet + Red gram (6:1) recorded significantly higher millet grain equivalent yield than sole red gram. These results are in conformity with findings of Kumar and Ray (2020) [7]and Kiranmai *et al*., (2021) [6].

In case of Fertilizer dose, M3 (100% STBF to Arhar+100% RD to little millet) recorded (1297 kg/ha) superior yield advantage 10.25% and 12.56% more than M2 and M1. The superior total system productivity observed under M3 clearly articulate the effectiveness of integrated application of nutrient resulting enhanced yields of both the component crops. Similar findings were observed by Sharmili and Parasuraman (2018) [13].

The interaction effect of planting pattern × Fertilizer dose was found to be significant and P2M3 recorded highest yield where as P3M1 recorded the lowest.

Gross return, Net return and B:C ratio

The Gross return, Net return and B:C ratio (Table-3) significantly higher under the planting pattern P2 (2:2) compared to P1 (1:1) and P3 (1:2) reflecting the higher economic efficient per unit rupees' investment. This system recorded 10.98% more gross return, 24.45% more net return and 10.16% more B:C ratio over P3 and at par with P1. The increased economics returns in intercropping system was primarily attributed to higher arhar equivalent yield, which is resulted higher returns and lower cost of cultivation in these treatments. Kiranmai *et al.*, (2021) [6] and Dewangan *et al.*, (2025) [2] also reported similar findings under integrated nutrient management system.

Significant variation of gross return, net return and B:C ratio was observed due to different fertilizer dose applied in inter cropping. The P2 (2:2) recorded highest gross return (Rs. 80,394/-), net return (Rs 36,194/-) and B:C ratio (1:82) which was superior to other two treatments. The results are conformity with the finding of Udikeri and Koppalkar (2017) [17] who applied 100% RDF to pigeon pea and 100% RDF to cluster bean in Pigeon pea +Cluster bean inter cropping system. Ram and Meena (2014) [11] also reported highest B:C ratio of pearl millet + mungbean (1:7) planting ratio in Bikaner, Rajastan.

Non-significant interaction effect between Planting pattern × Fertilizer dose was observed in case of Net return and B:C ratio but significant interaction effect was observed in AEY and Gross return. The highest yield and gross return of 1373 kg/ha and Rs. 85110/- obtained under P3M3 and the lowest is in P3M1.

Table 3: Influence of different planting pattern and nutrient management arhar equivalent yield, gross return, net return and benefit: cost ratio in Arhar

Treatment	AEY	Gross Return (Rs)	Net Return (Rs)	B:C ratio
Planting pattern (Arhar + Little millet)				
P1 (1:1)	1223	75804	32304	1.74
P2 (2:2)	1255	77826	33993	1.77
P3 (1:2)	1117	69279	25679	1.59
S.Em (±)	24	1505	1505	0.03
CD (0.05)	73	4512	4512	0.10
Fertilizer dose				
M1	1134	70336	27369	1.64
M2	1164	72179	28413	1.65
M3	1297	80394	36194	1.82
S.Em (±)	24	1505	1505	0.03
CD (0.05)	73	4512	4512	0.10
Interaction (P×M)				
P1M1	1239	76827	33727	1.78
P1M2	1103	68378	25178	1.58
P1M3	1326	82208	38008	1.86
P2M1	1121	69476	26376	1.61
P2M2	1272	78893	34693	1.78
P2M3	1373	85110	40910	1.93
P3M1	1044	64706	22006	1.52
P3M2	1117	69267	25367	1.58
P3M3	1191	73865	29665	1.67
S.Em (±)	42	2607	2607	0.06
CD (0.05)	126	7815	NS	NS

N.B.- P1(1:1) arhar + little millet, P2 (2:2) arhar + little millet, P3 (1:2) arhar + little millet, M1: (100% STBF to Arhar+0% RD to little millet), M2: 100% STBF to Arhar+50% RD to little millet), M3: (100% STBF to Arhar+100% RD to little millet).

Conclusion

This study indicated that application of 100% STBF to Arhar+100% RD to little millet to Arhar and little millet intercropping system (2:2 row ratio) increased the yield of both the crops and helped to get higher yield advantage indices and profit.

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