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Performance of Turmeric (*Curcuma longa L*) and Pigeon pea (*Cajanus Cajan L*.) Intercropping System under North Eastern Ghat Zone of Odisha, India

D. K. Debata [a] and L. K. Das [b*]

[a] RRTTS, G. Udayagiri (OUAT), Kandhamal-762100, Odisha, India
[b] College of Agriculture (OUAT), Bhawanipatna, Kalahandi-766001, Odisha, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Turmeric (*Curcuma longa* L) is a significant cash crop cultivated by tribal farmers of Odisha for their sustainanace. Despite favourable agro-climatic conditions, turmeric productivity lags considerably behind the national average, standing at 2.4t/ha compared to the national average of 5.1t/ha. Therefore, the present study was carried out during 2021-22 and 2022 -23 *kharif* seasons to evaluate the performance of the cropping system to find out suitable planting geometry and row proportions. The different treatments taken were *viz.*T_1 . Sole Turmeric, T_2- Sole Pigeon peaT_3- Turmeric + Pigeon pea (3:1) – one row of pigeon pea after three rows of turmeric (Additive)T_4- Turmeric + Pigeon pea (5:1)- one row of pigeon pea after five rows of turmeric (Additive)T_5- Turmeric + Pigeon pea (3:1) -one row of pigeon pea after three rows of turmeric (Replacement) T_6-

**Corresponding author: E-mail: lkdas.ouat@gmail.com;*

Turmeric + Pigeon pea (5:1)- one row of pigeon pea after five rows of turmeric (Replacement) T_7- Turmeric + Pigeon pea (6:2)- Two rows of pigeon pea after six rows of turmeric (Replacement) T_8- Turmeric + Pigeon pea (10:2)- one row of pigeon pea after ten rows of turmeric (Replacement).- Sole crop of turmeric fresh rhizome (106.04 q/ha)and pigeon pea grain (14.07 q/ha) produced the highest yield when compared with other intercropping systems. Turmeric +Pigeon pea (10:2) geometry gave the highest net return and benefit cost ratio over another intercropping system.

Keywords: Turmeric; pigeon pea; rhizomes; tribal; livelihood.

1. INTRODUCTION

Turmeric is an important commercial spice crop grown in India since ancient times and it is named as “Indian saffron”. It is known as the “golden spice” as well as the “spice of life.” “It reached China by 700 AD, East Africa by 800 AD and West Africa by 1200. It was introduced to Jamaica in the 18th Century and started becoming popular throughout the world. Turmeric was probably cultivated at first as a dye, and then became valued as a condiment as well as for cosmetic purposes. Turmeric was introduced to Europe by Arab traders in 13th century. Marco Polo, during his travels in China in 1280, was impressed by turmeric, and described it as a vegetable with saffron-like properties but distinct from saffron itself. Turmeric is globally recognized primarily as a spice, commonly used in various culinary applications such as curry powder, chicken bouillon, sauces, gravies, dry seasoning, baking mixes, processed cheese pickles, relishes, breading soup, beverages and confections” [1]. “Turmeric is now grown in countries like India, China, Pakistan, Bangladesh, Vietnam, Thailand, Philippines, Japan, Korea, Sri Lanka, Nepal, South Pacific Islands, East and West Africa, Malaysia, Caribbean Islands and Central America. The world production of turmeric is 800000 tonnes in which India holds a share of approximately 75- 80% and consumes around 80% of its production. India is by far the largest producer and exporter of turmeric in the world. Indian turmeric is considered the best in the world market because of its high curcumin content(6.7%). Turmeric occupies about 6% of the total area under spices and condiments in country. During 2012-2013, the country produced 9,92,900 tonnes of turmeric from an area of 1,95,100 ha” [2]. During the period from April 2011 to January 2012, India ex-ported 67,000 tonnes of turmeric valued at Rs 6,438 million. Of India's total turmeric exports, 65% were exported to UAE, USA, Japan, Srilanka, UK, and Malaysia. Andhra Pradesh, Tamil Nadu, Odisha, Karnataka, West Bengal, Gujarat, Meghalaya, Maharashtra and Assam are important states cultivating turmeric. Andhra Pradesh alone occupies 35.0% of area and 47.0% of production.

“In Odisha, turmeric is an important cash crop grown by tribal families for their livelihood and more than 50% of this crop grower are tribals. Odisha contributes about 21 % of India’s turmeric cultivation in terms of area and Kandhamal makes up over 50 % of the state' s share. Odisha produced turmeric 59361 t from 24733 ha. Kandhamal district stands first in turmeric area as well as production (28,828 t from 11,088 ha). Koraput is the second largest producing district (7,761 t from 3,168 ha) followed by Nayagarh (5343 t from 2473 ha) and Keonjhar (2937 t from 1224 ha). Turmeric serves as a vital cash crop cultivated by Kondha tribes in Kandhamal district and the Langi Kondha in Gajapati district. Utilising their traditional farming methods,these tribes cultivate turmeric in their backyards, predominantly employing organic practices,which yields them favourable returns. Recognising the potential of turmeric, the state has proposed an Agri Export Zone (AEZ) covering Kandhamal district” [3]. “Furthermore turmeric holds cultural significance being involved in religious rituals and magical rites in India and various Southeast Asian countries. Traditionally, it has been utilized in India for both human and veterinary healthcare, as a natural dye,and in the preparation of savory dishes. Though traditional Indian Ayurvedic and Siddha systems of medicine have recognized the medicinal value of turmeric in its crude form since very ancient times, a few decades have witnessed extensive research interests worldwide in the biomedical activity of turmeric and its compounds. Thus Curcumais now gaining importance all over the world as a mighty cure to combat a variety of ailments, as the genus carries molecules credited with anti-inflammatory, hypocholestremic, choleratic, antimicrobial, antirheumatic, antifibrotic, antivenomous, antiviral antidiabetic, antihepatoxic and anticancerous properties as well as insect repellent activity” [4]. Turmeric can be grown in Odishaas an intercrop in coconut and areca nut

plantations. Turmeric is the third-largest spice exported from India. In terms of quantity and value, it accounts for about 12% and 5% respectively.

Due to the rapidly increasing population of the country, the pressure on agricultural land to get maximum yield per unit is increasing continuously. On the other hand, due to climate change, there is also a significant change in the uncertainty of rainfall. Intercropping farming is considered very useful in dealing with such challenges. In pigeon pea growing areas of the country, farmers often plant pigeon pea on the bunds of paddy fields. This gives less yield. But if turmeric farming is done with pigeon pea, then farmers can earn double.

Intercropping Farming is such a scientific technique, which is very effective in increasing the income of the farmers. In this regard, it is recommended by agricultural experts to do turmeric with pigeon pea or ginger with pigeon pea or turmeric with drumstick or inter-cultivation of ginger and turmeric with papaya. With this modern technology, farmers can increase their income apart from reducing the risk of farming.

Actually, turmeric can be cultivated easily even in shady environments. Turmeric is a popular medicinal and spice crop. That's why it gets a good price in the market. Cultivation of turmeric with pigeon pea as an intercropping crop yields income from both the costly crops. The inclusion of pigeon pea cultivation in the crop rotation maintains the fertility of the soil, because the roots of pulse crops provide natural fertility to the soil by absorbing nitrogen directly from the atmosphere.

“Tribal farmers grow turmeric as a sole crop or take pigeonpea, colocassia and cowpea with turmeric in mixed cropping systems” (Behera et al. 2004). “Turmeric + pigeonpea mixed cropping system gives several advantages *viz*. soil health build-up due to legume component, creation of favourable microclimate for turmeric due to partial shade from pigeonpea and satisfaction of domestic pulse need. The farmers grow the component crops neither in regular rows nor in proper row ratio. Yield of component crops decreases due to mutual competition” (Behera et al. 2004). Hence the experiment has been designed to find out suitable row ratio and planting pattern for turmeric + pigeonpea intercropping system.

2. MATERIALS AND METHODS

One experiment was conducted at the Regional Research Technology and Transfer Station (RRTTS), G.Udayagiri, Kandhamal, Odisha to study the performance of the cropping system to find out suitable row proportions of turmeric and arhar with additive and replacement series.

Experimental Design was a Randomised Block Design with three replications and eight treatments. The experiment was conducted in medium land site and the soil was sandy loam in texture, pH 5.39, low available P_2O_5, organic carbon-5.4g/kg, and available K_2O is 160kg ha^{-1}

The treatments used were

T_1 - Sole Turmeric,

T_2- Sole Pigeon pea

T_3- Turmeric + Pigeon pea (3:1) – one row of pigeon pea after three rows of turmeric (Additive)

T_4- Turmeric + Pigeon pea (5:1)- one row of pigeon pea after five rows of turmeric (Additive)

T_5- Turmeric + Pigeon pea (3:1) -one row of pigeon pea after three rows of turmeric (Replacement)

T_6- Turmeric + Pigeon pea (5:1)- one row of pigeon pea after five rows of turmeric (Replacement)

T_7- Turmeric + Pigeon pea (6:2)- Two rows of pigeon pea after six rows of turmeric (Replacement)

T_8- Turmeric + Pigeon pea (10:2)- one row of pigeon pea after ten rows of turmeric (Replacement)

Recommended Ecosystem – Rain-fed upland and Parameters measured included plant height, number of branches/plant at harvest, number of pods/plant, number of seeds/pods, 1000 seed mass, rooting depth, mass of mother rhizome, mass of primary rhizome, mass of secondary and tertiary rhizome**.** The data was subjected to Analysis of Variance (ANOVA) in Statistical Analysis System (SAS) software.

3. RESULTS AND DISCUSSION

The morphological characters of turmeric were found to be significantly influenced by various intercrops. The pigeon-pea as pure crop recorded significantly higher values for plant

height (174.9 cm), no of branches/plant at harvest-(15.3), no. of pods /plant3-(12.3), no of seeds /pod-(4.7), 1000seed mass-(82.11)g, mass of secondary rhizome /plant-(405.1), yield of14.07q $ha^{-1}$and B:C ratio-1.40 . The turmeric as pure crop recorded plant height-78.30cm, Rooting depth-13.11cm, length of leaves—36.31cm, weight of mother rhizome-34.40g, weight of primary rhizome-132.30g, and weight of secondary and tertiary rhizome-75.20g, total weight clump-241.80g, fresh turmeric rhizome-106,04q ha^{-1} and B:C ratio -1.37. The turmeric: Pigeon pea (10:2) in T8 having one row of pigeon pea after ten rows of turmeric (Replacement) recorded significantly higher values for plant height, Rooting depth, length of leaves, mass of mother rhizome, mass of primary rhizome, and mass of secondary and tertiary rhizome,total mass clump-221.20g , fresh turmeric rhizome, Grain yield of Pigeon pea (q $ha^{-1)}$ -4.54 and B:C ratio -(2.11. ha^{-1}), dry turmeric rhizome yield (16.81q ha^{-1}), dry turmeric rhizome equivalent yield was (19.91q ha^{-1})$_{,}$ and Islam et al*.* [5] indicated that "higher biomass production and consequently more efficient use of land and available resources under intercropping than under sole cropping contributed to the higher turmeric yield". Similar results were obtained by Balashanmugam et al. [6] and Narayanpur and Sulikeri [7] in turmeric and Kumar et al. [8] in ginger. Paraye et al. [9] reported that "ginger equivalent yield and net return was higher in ginger (Raigarh local) + turmeric (Sudershana) in 1:1 row ratio intercropping system".

"When the base crop and intercrops were adequately fertilised then there is no yield reduction in the main crop" [10]. Similar results were observed by Kannan et al., [11], Chattopadhyay et al., [4] "in elephant foot yam intercropped with vegetables". It was interpreted by Singh et al*.,* (2013) that "less competition for resources and better scope of intercultural operations at early growth stages were the favourable points, which might have triggered the process of partitioning photosynthates from source to sink resulting in higher yield of main crop". Further, Das and Maharana [12] explained that "elephant foot yam does not compete for light because it can tolerant shade". "The higher productivity of the intercrop system compared to the sole crop might have resulted from complementary and efficient use of growth resources by the component crops" as explained by Li et al*.,* [13]. Willey [14] also elucidated that "mixed cropping was more efficient and productive than sole cropping because of higher combined yield and better energy use efficiency". Ravindran et al., [15] also advocated intercropping of tuber crops for better remuneration.

Table 1. Effect of planting geometry on growth and yield attributes of pigeon pea in turmeric + pigeon pea intercropping system(Pooled over 2021-22 &2022-23)

Treatments	Plant height (cm) at harvest	No of branches $plant^{-1}$ at harvest	No of field pods/plant	No of seeds/for pods	1000- Seed weight (g)
T1	-	-	-	-	-
T_2	174.9	15.3	132.3	4.7	82.11
T_3	169.4	14.6	130.3	4.6	82.10
T_4	161.2	14.0	125.7	4.4	81.78
T_5	166.4	14.5	130.3	4.5	81.98
T_6	156.1	13.5	122.2	4.3	81.55
T_7	165.2	14.1	127.8	4.5	81.78
T_8	151.5	13.1	120.4	4.1	81.34
SEm (±)	5.29	0.46	2.78	0.22	1.65
CV	10.78	0.95	5.77	0.46	NS

T_1 - Sole Turmeric,
T_2- Sole Pigeon pea
T_3- Turmeric + Pigeon pea (3:1) – one row of pigeon pea after three rows of turmeric (Additive)
T_4- Turmeric + Pigeon pea (5:1)- one row of pigeon pea after five rows of turmeric (Additive)
T_5- Turmeric + Pigeon pea (3:1) -one row of pigeon pea after three rows of turmeric (Replacement)
T_6- Turmeric + Pigeon pea (5:1)- one row of pigeon pea after five rows of turmeric (Replacement)
T_7- Turmeric + Pigeon pea (6:2)- Two rows of pigeon pea after six rows of turmeric (Replacement)
T_8- Turmeric + Pigeon pea (10:2)- one row of pigeon pea after ten rows of turmeric (Replacement)

Table 2. Effect of planting geometry on growth and yield attributes of Turmeric in turmeric + pigeon pea intercropping system (Pooled over 2021-22 &2022-23)

Treatments	Plant height (cm)	Rooting depth (cm)	Weight of mother rhizome (g)	Weight of primary rhizome (g)	Weight of secondary and tertiary rhizome (g)	Total weight (g) clump
T_1	78.30	13.11	34.40	132.30	75.20	241.80
T_2	-		-	-	-	-
T_3	63.75	8.70	23.98	107.56	46.76	178.24
T_4	67.68	11.53	26.21	126.34	60.67	216.22
T_5	66.21	9.89	25.21	119.23	54.45	201.22
T_6	67.37	10.57	28.34	121.01	56.28	205.63
T_7	65.34	9.23	24.11	117.34	52.75	194.23
T_8	74.59	12.46	30.60	127.40	64.20	221.20
SEm (±)	2.15	0.54	1.24	3.68	2.46	4.55
CD (0.05)	6.30	1.59	3.64	10.78	7.20	13.34

T_1 - Sole Turmeric, T_2- Sole Pigeon peaT_3- Turmeric + Pigeon pea (3:1) – one row of pigeon pea after three rows of turmeric (Additive)
T_4- Turmeric + Pigeon pea (5:1)- one row of pigeon pea after five rows of turmeric (Additive)
T_5- Turmeric + Pigeon pea (3:1) -one row of pigeon pea after three rows of turmeric (Replacement)
T_6- Turmeric + Pigeon pea (5:1)- one row of pigeon pea after five rows of turmeric (Replacement)
T_7- Turmeric + Pigeon pea (6:2)- Two rows of pigeon pea after six rows of turmeric (Replacement)
T_8- Turmeric + Pigeon pea (10:2)- one row of pigeon pea after ten rows of turmeric (Replacement)

Yield and economics of turmeric + pigeon pea intercropping system (Pooled over 2021-22 &2022-23)

Treatment	Fresh Turmeric Rhizome (q/ha)	Grain yield of Pigeon pea (q/ha)	Dry Turmeric Rhizome (q/ha)	Turmeric (dry rhizome) equivalent yield (q/ha)	Gross Return (Turmeric) (Rs/ha)	Gross Return (Pigeon pea) (Rs/ha)	Gross Return (Turmeric &Pigeon pea) (Rs/ha)	Net Return (Rs/ha)	B:C Ratio
T1-Sole turmeric	106.04	-	22.21		371140	-	371140	40140	1.37
T2- Sole Pigeon pea	-	14.07	-	9.62	-	92862	92862	41863	1.40
T3- T+P(3:1) Additive	42.99	11.13	8.60	16.26	150465	73458	223923	51563	1.51
T4- T+P(5:1)Additive	59.90	7.30	11.83	16.88	209650	48180	257830	57590	1.54
T5T+P(3:1)Replacement	53.22	8.81	10.65	16.66	186270	58146	244416	69736	1.67
T6T+P(5:1)Replacement	61.59	5.97	12.32	16.40	215565	39402	254967	75927	1.87
T7-T+P(6:1Replacement	52.60	8.28	10.52	16.21	184100	54648	238748	66068	1.71
T8-T+P(10:2) Replacement	84.02	4.54	16.81	19.91	294070	29964	324034	98994	2.11
SEm (±)	6.74	1.08	0.55	0.71	3396	2983	2359	2431	0.04
CV	18.04	3.16	1.16	1.50	7199	6323	5001	5154	0.08

4. CONCLUSION

The Adoption of a turmeric and pigeon pea 10:2 planting pattern for turmeric and pigeon pea intercropping has emerged as the most stable, productive and economically rewarding system. This planting geometry ensures optimum spacing between turmeric and pigeon pea plants, allowing for efficient resource utilization, and minimal competition between crops. Through this arrangement, farmers can achieve stable yields and maximize productivity while also enhancing profitability. Research findings indicate that this specific planting pattern promotes synergy between turmeric and pigeon peas, leading to mutually beneficial growth and development. Overall, adopting the 10:2 planting pattern offers a promising approach to optimize the inter-cropping system s and economic returns for farmers. A sole crop of turmeric fresh rhizome (106.04 q/ha)and pigeon pea grain (14.07 q/ha) produced the highest yield when compared with other intercropping systems. Turmeric +Pigeon pea (10:2) geometry gave the highest net return and benefit-cost ratio over other intercropping systems and pigeon pea (10:2) planting pattern to turmeric and pigeon pea intercropping system recommended for higher productivity and net return also.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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