

Effect of liquid organic manures on sole and intercropping systems of baby corn and garden pea

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Abstract

A field experiment was conducted at Ramakrishna Mission Vivekananda Educational and Research Institute, Ranchi, during the winters of 2022-23 and 2023-24 to study the influence of liquid manures on crops under sole and intercropping systems of baby corn and garden peas. The experiment was placed in split plot design using 4 cropping systems in main plot (CS1: sole baby corn, CS2: sole garden pea, CS3: intercropping of baby corn and garden pea (1:1), CS4: intercropping of baby corn and garden pea (2:1)) and 4 liquid manure options in subplot (M1: control or no liquid manure, M2: Jiwamrit @ 10 %, M3: Kunapajala @ 10 %, M4: Panchagavya @ 10 %), replicated thrice. Pooled results indicated that the intercropping system of baby corn and garden pea, especially at a 1:1 ratio, grown using Kunapajala at 10% ensured the highest growth, yield attributes, and cob yield (2.09 t/ha) of baby corn over sole cropping. However, sole cropping grown using Kunapajala at 10% was found to be the best in realising the highest growth, yield attributes, seed yield (80.0 q/ha), and pod yield (145.5 q/ha) of garden peas over intercropping systems. Among the intercropping systems, 1:1 intercropping system of baby corn and garden pea performed better than 2:1 intercropping system. Further, among different intercropping systems, spraying of Kunapajala @ 10 % at 15, 30 and 45 days after sowing in 1:1 intercropping system of baby corn and garden pea ensured best system cob equivalent yield (4.17 t/ha), 60% yield advantage and high economic profitability (B:C of 6.06) and therefore, farmers of eastern plateau and hill zone of India can be benefitted by growing this intercropping system with the use of Kunapajala @ 10 %.

Key words: Baby corn, garden pea, economics and yield, intercropping, Kunapajala, liquid manure

Introduction

Chemical-based agriculture in India has led to soil degradation and long-term environmental issues (Biswas *et al.*, 2019). Organic farming, a sustainable and eco-friendly approach, is being taken seriously after a century of neglect. Organic liquid manures, such as Jiwamrit, Kunapajala, and Panchagavya, are being used as bio-stimulants to improve soil and crop health (Ram *et al.*, 2018). These formulations are rich in beneficial microorganisms, macro- and micro-nutrients, plant growth promoters, antioxidants, and plant protection properties, and have shown positive effects on many crops (Solanki *et al.*, 2015; Anandan *et al.*, 2016; Atwa *et al.*, 2023; Jasani *et al.*, 2024). Because of India's growing population and shrinking agricultural land, 'land use planning' has become a basic and essential aspect for productive agriculture. The time has come to maximize agricultural production through 'Intensive cropping' along with increased productivity. Intercropping is one of the 'Intensive cropping' approaches to increase production. The cereal-legume intercropping system can play a key role in uplifting the system's productivity as well as improving the soil fertility through fixing nitrogen from the atmosphere to the soil by rhizobium present in the root nodule of the legume crop.

Baby corn is a short-duration crop that can be grown multiple times per year and can be a good substitute for fodder maize. It is a cash crop and a good catch crop. Garden pea, a winter legume, is a significant vegetable due to its high protein content. India

ranks second in global garden pea production, with Jharkhand being a significant producer. Both crops are popular for their tender, sweet, and nutritious green cobs. It is expected that cereal and legume cultivation can be boosted up by organic liquid formulations, and under an organic farming system, the intercropping system of baby corn and garden pea can therefore create a win-win situation to ensure good growth and productivity of the crops as well as environmental safety as it curtails the use of chemicals. However, the effects of various organic liquid manures on the yield of particular crop combinations (such as garden peas and baby corn) in Indian agroecosystems are not well documented. A comparative analysis can, therefore, determine the best organic nutrient management option from these for cereal-legume intercropping systems. Although some research has examined organic versus chemical practices, a more thorough evaluation of organic liquid formulations and their long-term impacts on environmental sustainability and crop productivity is required. This study offers fresh perspectives on the real-world implementation of organic farming in Indian agro-ecosystems, addressing local conditions and requirements by concentrating on Jiwamrit, Kunapajala, and Panchagavya in conjunction with baby corn and garden pea intercropping.

The objective of the study was to investigate the influence of liquid manures on the growth, yield, and economic profitability of crops under sole and intercropping systems of baby corn and garden pea.

Materials and methods

The field investigation was conducted during the *rabi* season of 2022-2023 and 2023-24 at the campus of Ramakrishna Mission Vivekananda Educational and Research Institute (RKMVERI), Morabadi, Ranchi, in a split plot design using 4 cropping systems in the main plot (CS₁: sole baby corn, CS₂: sole garden pea, CS₃: 1:1 intercropping system of baby corn and garden pea, CS₄: 2:1 intercropping system of baby corn and garden pea) and 4 liquid manure applications in the sub-plot (M₁: control or no liquid manure, M₂: Jiwamrit @ 10 %, M₃: Kunapajala @ 10 %, M₄: Panchagavya @ 10 %), replicated three times. The experimental soil was sandy loam in nature, having a pH of 6.67, organic carbon of 0.52 %, available N of 211.2 kg/ha, available P of 48.2 kg/ha, and available K of 141.3 kg/ha. Baby corn (var. F-38) seeds treated with *Trichoderma* @ 5% and garden pea (var. GS-10) seeds treated with *Rhizobium leguminosarum* were sown at a spacing of 60 cm × 25 cm and 30 cm × 10 cm, respectively. Recommended dose of fertilizers (RDF) for sole baby corn and intercropping systems was 120:60:60 kg/ha N:P₂O₅:K₂O, while RDF for sole garden pea was 20:60:40 kg/ha N:P₂O₅:K₂O and the nutrients were supplied through basal application of farmyard manure (0.9 % N, 0.6 % P₂O₅, and 0.8 % K₂O), three times application of Jiwamrit, Panchagavya, and Kunapajala at 15, 30, and 45 days after sowing (DAS) as per the treatments. Preparation processes of liquid manures followed the protocols of Biswas *et al.* (2023). Agronomic and plant protection measures were used as per the standard practices followed in the region.

Observations consisted of plant height, numbers of leaves/plant of both the crops at 30, 45, and 60 DAS, number of cobs/plant, cob length, cob yield of baby corn, numbers of pods/plant, number of seeds/pod, 1000 seeds weight, pod length, pod girth, seed and pod yields of garden pea. Afterwards, system cob equivalent yield was calculated by converting legume's yield to cereals through the following formula:

$$\text{Crop equivalent yield} = (\sum Y_i P_i) / P_j$$

Where, Y_i = Yield of ith crop

P_i = Price of ith crop

P_j = Price of jth crop

To estimate whether the intercropping was advantageous or not, land equivalent ratio (LER) was chalked out using the following formula (Willey and Osiru, 1972):

$$\text{LER} = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$$

Where, Y_{ab} = Intercrop yield of species 'a' in presence of species 'b'

Y_{ba} = Intercrop yield of species 'b' in presence of species 'a'

Y_{aa} = Pure stand yield of species 'a'

Y_{bb} = Pure stand yield of species 'b'

Production economics (cost of cultivation, gross return, net return and B:C) were calculated using the standard processes (Biswas *et al.*, 2024). Data obtained from field were statistically analyzed using analysis of variance and the treatment means were compared using critical difference (C.D.) values at 5% level of significance ($P=0.05$) (Panse and Sukhatme, 1985).

Results

Growth attributes of baby corn: At 30, 45, and 60 DAS, the highest plant height (33.0, 58.3, and 70.7 cm) and number

of leaves/plant (4.9, 7.2, and 8.4) were obtained under the intercropping system of baby corn and garden pea (1:1) (CS₃), followed by the intercropping system of baby corn and garden pea (2:1) (CS₄) (Table 1). Sole baby corn (CS₁), on the other hand, recorded the lowest growth attributes. At 30, 45, and 60 DAS, baby corn exhibited the highest plant height (34.0, 62.0, and 77.7 cm) and number of leaves/plant (5.1, 7.4, and 8.3) under application of Kunapajala (M₃), closely followed by Jiwamrit spray (M₂) and Panchagavya spray (M₄), while the lowest growth attributes were obtained by control (M₁). At 30, 45, and 60 DAS, the highest plant height (35.8, 65.2 and 81.4 cm) and number of leaves/plant (5.4, 7.8, and 8.7) were obtained when Kunapajala was applied in the intercropping system of baby corn and garden pea (1:1) (CS₃M₃). Sole baby corn under no liquid manure application (CS₁M₁), on the other hand, recorded the lowest growth attributes.

Growth attributes of garden pea: At 30, 45, and 60 DAS, the highest plant height (26.9, 47.9, and 60.9 cm) and number of leaves/plant (11.3, 21.9, and 25.8) were obtained under sole cropping of garden pea (CS₂), followed by the intercropping system of baby corn and garden pea (1:1) (CS₃) (plant height: 24.2, 45.9, and 54.1 cm; leaves/plant: 10.7, 19.6, and 23.5). The intercropping system of baby corn and garden pea (2:1) (CS₄) on the other hand, recorded the lowest growth attributes. At 30, 45, and 60 DAS, garden pea exhibited the highest plant height (27.5, 51.5, and 63.3 cm) and number of leaves/plant (11.6, 22.4, and 28.3) under application of Kunapajala (M₃), closely followed by Jiwamrit spray (M₂) and Panchagavya spray (M₄), while the lowest growth attributes were obtained by control (M₁). At 30, 45, and 60 DAS, the highest plant height (30.5, 54.4, and 68.5 cm) and number of leaves/plant (12.1, 24.9, and 31.4) were obtained when Kunapajala was applied in the sole cropping system of garden pea (CS₂M₃), closely followed by the intercropping system of baby corn and garden pea (1:1) under the Kunapajala application (CS₃M₃). The intercropping system of baby corn and garden pea (2:1) under no liquid manure application (CS₄M₁), on the other hand, recorded the lowest growth attributes (Table 2).

Yield attributes of baby corn: Significant variations existed among yield attributes and yield of baby corn under different cropping systems, liquid manure uses, and their combinations (Table 3). The highest number of cobs/plant (2.66), cob length (14.6 cm), and cob yield (1.74 t/ha) were noted from the intercropping system of baby corn and garden pea (1:1) (CS₃), closely followed by the intercropping system of baby corn and garden pea (2:1) (CS₄), while the lowest yield attributes were expressed by sole baby corn (CS₁). Among liquid manures, the application of Kunapajala (M₃) resulted in the highest number of cobs/plant (2.68), cob length (15.0 cm), and cob yield (1.86 t/ha), closely followed by Panchagavya (M₄) and Jiwamrit (M₂) spray. Lowest yield attributes were shown by control (M₁). When the combined influence of cropping systems and liquid manures was considered, baby corn from the intercropping system of baby corn and garden pea (1:1) grown using Kunapajala (CS₃M₃) exhibited the highest number of cobs/plant (2.84), cob length (16.0 cm), and cob yield (2.09 t/ha), closely followed by the intercropping system of baby corn and garden pea (2:1) grown using Kunapajala (CS₄M₃). The lowest yield attributes were recorded from sole baby corn under no liquid manure application (CS₁M₁).

Table 1. Influence of liquid manures on growth characters of baby corn under sole and intercropping systems of baby corn and garden pea (pooled)

Treatments	Plant height (cm) at 30 DAS					Number of leaves/plant at 30 DAS				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	23.7	30.5	32.3	24.5	27.8	4.4	4.7	5.0	4.6	4.7
CS ₂	-	-	-	-	-	-	-	-	-	-
CS ₃	30.0	34.4	35.8	31.7	33.0	4.6	4.7	5.4	4.7	4.9
CS ₄	29.8	32.4	33.9	30.6	31.7	4.5	4.6	5.1	4.6	4.7
Mean	27.8	32.4	34.0	28.9		4.5	4.7	5.1	4.6	
	CS	M		CS× M	M × CS	CS	M		CS× M	M × CS
S.Em ±	0.22	0.08		0.44	0.25	0.04	0.05		0.08	0.08
C.D. (P= 0.05)	0.9	0.2		0.5	0.9	NS	0.1		NS	NS
Treatments	Plant height (cm) at 45 DAS					Number of leaves/plant at 45 DAS				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	34.3	47.2	57.7	45.0	46.1	5.8	6.3	7.1	6.0	6.3
CS ₂	-	-	-	-	-	-	-	-	-	-
CS ₃	52.5	59.4	65.2	56.0	58.3	6.9	7.0	7.8	7.0	7.2
CS ₄	37.5	53.6	63.2	46.6	50.2	5.9	6.9	7.4	6.1	6.6
Mean	41.5	53.4	62.0	49.2		6.2	6.7	7.4	6.4	
	CS	M		CS× M	M × CS	CS	M		CS× M	M × CS
S.Em ±	0.10	0.26		0.20	0.40	0.06	0.06		0.13	0.11
C.D. (P= 0.05)	0.4	0.8		1.4	1.2	0.3	0.2		0.3	0.4
Treatments	Plant height (cm) at 60 DAS					Number of leaves/plant at 60 DAS				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	46.0	61.3	74.3	55.8	59.4	6.2	7.4	7.9	7.2	7.2
CS ₂	-	-	-	-	-	-	-	-	-	-
CS ₃	62.8	70.2	81.4	68.4	70.7	8.0	8.5	8.7	8.4	8.4
CS ₄	49.2	62.8	77.4	57.2	61.7	6.7	8.0	8.3	7.3	7.6
Mean	52.7	64.8	77.7	60.5		7.0	8.0	8.3	7.6	
	CS	M		CS× M	M × CS	CS	M		CS× M	M × CS
S.Em ±	0.87	0.83		1.73	1.52	0.03	0.09		0.06	0.14
C.D. (P= 0.05)	3.5	2.5		4.8	5.1	0.1	0.3		0.5	0.4

CS: Cropping systems, M: Liquid manures

Table 2. Influence of liquid manures on growth characters of garden pea under sole and intercropping systems of baby corn and garden pea (pooled)

Treatments	Plant height (cm) at 30 DAS					Number of leaves/plant at 30 DAS				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-	-	-	-	-	-
CS ₂	24.0	27.4	30.5	25.5	26.9	10.5	11.5	12.1	11.2	11.3
CS ₃	21.5	24.5	27.7	23.0	24.2	9.7	11.0	11.7	10.4	10.7
CS ₄	19.1	22.2	24.1	20.2	21.4	9.1	10.5	11.1	9.9	10.1
Mean	21.5	24.7	27.5	22.9		9.8	11.0	11.6	10.5	
	CS	M		CS× M	M × CS	CS	M		CS× M	M × CS
S.Em ±	0.11	0.12		0.22	0.22	0.33	0.42		0.67	0.71
C.D. (P= 0.05)	0.5	0.4		0.7	0.7	NS	1.2		NS	NS
Treatments	Plant height (cm) at 45 DAS					Number of leaves/plant at 45 DAS				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-	-	-	-	-	-
CS ₂	41.6	48.4	54.4	47.3	47.9	19.8	22.2	24.9	20.7	21.9
CS ₃	39.4	47.7	53.0	43.5	45.9	17.4	20.4	21.9	18.5	19.6
CS ₄	36.1	44.4	47.0	43.2	42.7	16.9	19.2	20.4	17.9	18.6
Mean	39.0	46.8	51.5	44.7		18.0	20.6	22.4	19.0	
	CS	M		CS× M	M × CS	CS	M		CS× M	M × CS
S.Em ±	0.13	0.27		0.25	0.43	0.11	0.15		0.22	0.25
C.D. (P= 0.05)	0.4	0.8		1.5	1.3	0.4	0.4		0.8	0.8
Treatments	Plant height (cm) at 60 DAS					Number of leaves/plant at 60 DAS				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-	-	-	-	-	-
CS ₂	51.8	65.0	68.5	58.4	60.9	21.1	26.0	31.4	24.8	25.8
CS ₃	48.0	53.8	62.4	52.2	54.1	19.2	24.9	27.3	22.8	23.5
CS ₄	46.0	51.0	58.9	50.3	51.6	18.9	22.9	26.1	21.5	22.3
Mean	48.6	56.6	63.3	53.6		19.7	24.6	28.3	23.0	
	CS	M		CS× M	M × CS	CS	M		CS× M	M × CS
S.Em ±	0.16	0.30		0.32	0.48	0.09	0.26		0.18	0.40
C.D. (P= 0.05)	0.6	0.9		1.6	1.5	0.4	0.8		1.4	1.2

CS: Cropping systems, M: Liquid manures

Table 3. Influence of liquid manures on yield characters and yield of baby corn under sole and intercropping systems of baby corn and garden pea (pooled)

Treatments	Number of cobs/plant				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	2.12	2.33	2.45	2.53	2.36
CS ₂	-	-	-	-	-
CS ₃	2.46	2.61	2.84	2.72	2.66
CS ₄	2.33	2.48	2.75	2.61	2.54
Mean	2.30	2.47	2.68	2.62	
	CS	M		CS× M	M × CS
S.Em ±	0.02	0.02		0.05	0.03
C.D. (P= 0.05)	0.10	0.05		0.10	0.12

Treatments	Cob length (cm)				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	11.3	12.4	14.1	13.4	12.8
CS ₂	-	-	-	-	-
CS ₃	13.2	14.5	16.0	14.6	14.6
CS ₄	13.0	13.3	14.8	14.3	13.9
Mean	12.5	13.4	15.0	14.1	
	CS	M		CS× M	M × CS
S.Em ±	0.13	0.09		0.25	0.19
C.D. (P= 0.05)	0.5	0.3		0.6	0.6

Treatments	Cob yield (t/ha)				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	1.45	1.59	1.72	1.53	1.57
CS ₂	-	-	-	-	-
CS ₃	1.56	1.63	2.09	1.68	1.74
CS ₄	1.56	1.61	1.77	1.58	1.63
Mean	1.52	1.61	1.86	1.60	
	CS	M		CS× M	M × CS
S.Em ±	0.003	0.009		0.005	0.013
C.D. (P= 0.05)	0.01	0.03		0.05	0.04

Yield attributes of garden pea: The highest number of pods/plant (8.5), number of seeds/pod (6.6), pod length (6.6 cm), pod girth (3.9 cm), 100 fresh seeds' weight (49.6 g), seed yield (57.5 q/ha), and pod yield (104.5 q/ha) were obtained under sole cropping of garden pea (CS₂), followed by intercropping system of baby corn and garden pea (1:1) (CS₃). The intercropping system of baby corn and garden pea (2:1) (CS₄), on the other hand, recorded the lowest yield attributes. Garden pea exhibited the highest number of pods/plant (8.5), number of seeds/pod (6.7), pod length (6.7 cm), pod girth (3.9 cm), 100 fresh seeds' weight (49.7 g), seed yield (60.5 q/ha), and pod yield (75.1 q/ha) under application of Kunapajala (M₃), closely followed by Panchagavya spray (M₄) and Jiwamrit spray (M₂), while the lowest yield attributes were obtained by control (M₁). The highest number of pods/plant (9.2), number of seeds/pod (7.1), pod length (6.8 cm), pod girth (4.1 cm), 100 fresh seeds' weight (50.5 g), seed yield (80.0 q/ha), and pod yield (145.5 q/ha) were obtained when Kunapajala was applied in the sole cropping system of garden pea (CS₂M₃), followed mostly by Kunapajala sprayed in the intercropping system of baby corn and garden pea (1:1) (CS₃M₃). The intercropping system of baby corn and garden pea (2:1) under no liquid manure application (CS₄M₁), on the other hand, recorded the lowest yield attributes (Tables 4 and 5).

System cob equivalent yield and land equivalent ratio: System cob equivalent yield explored that the sole garden pea outperformed others (3.92 t/ha), followed by the intercropping system of baby corn and garden pea (1:1) (CS₃), while the least system cob equivalent yield was recorded from the sole baby corn (CS₁) (Table 6). Among the liquid manures, the Kunapajala

Table 4. Influence of liquid manures on yield characters of garden pea under sole and intercropping systems of baby corn and garden pea (pooled)

Treatments	Number of pods/plant				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-
CS ₂	7.7	8.5	9.2	8.4	8.5
CS ₃	7.3	8.0	8.7	7.8	8.0
CS ₄	6.9	7.1	7.5	8.0	7.4
Mean	7.3	7.9	8.5	8.1	
	CS	M		CS× M	M × CS
S.Em ±	0.04	0.05		0.09	0.09
C.D. (P= 0.05)	0.2	0.2		0.3	0.3

Treatments	Number of seeds/pod				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-
CS ₂	6.1	6.7	7.1	6.4	6.6
CS ₃	6.1	6.5	6.7	6.3	6.4
CS ₄	5.8	6.0	6.4	6.2	6.1
Mean	6.0	6.4	6.7	6.3	
	CS	M		CS× M	M × CS
S.Em ±	0.12	0.11		0.24	0.21
C.D. (P= 0.05)	NS	0.3		NS	NS

Treatments	Pod length (cm)				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-
CS ₂	6.4	6.6	6.8	6.6	6.6
CS ₃	5.9	6.4	6.7	6.5	6.4
CS ₄	5.7	6.2	6.6	6.4	6.2
Mean	6.0	6.4	6.7	6.5	
	CS	M		CS× M	M × CS
S.Em ±	0.07	0.05		0.13	0.10
C.D. (P= 0.05)	0.3	0.1		NS	NS

Treatments	Pod girth (cm)				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-
CS ₂	3.7	4.0	4.1	3.8	3.9
CS ₃	3.7	3.8	3.9	3.6	3.7
CS ₄	3.6	3.7	3.8	3.6	3.7
Mean	3.7	3.8	3.9	3.7	
	CS	M		CS× M	M × CS
S.Em ±	0.06	0.07		0.11	0.11
C.D. (P= 0.05)	NS	0.2		NS	NS

Treatments	100 fresh seeds' weight (g)				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-
CS ₂	48.9	49.7	50.5	49.3	49.6
CS ₃	48.2	49.0	49.5	48.7	48.9
CS ₄	47.9	48.6	49.1	48.3	48.5
Mean	48.3	49.1	49.7	48.8	
	CS	M		CS× M	M × CS
S.Em ±	0.10	0.14		0.21	0.23
C.D. (P= 0.05)	0.4	0.4		NS	NS

spray (M₃) recorded the best system cob equivalent yield (3.51 t/ha), followed by Jiwamrit spray (M₂). Altogether, sole garden pea under Kunapajala spray (CS₂M₃) recorded the highest system cob equivalent yield (5.46 t/ha). Among the intercropping systems, the intercropping system of baby corn and garden pea (1:1) grown using Kunapajala (CS₃M₃) exhibited the highest system cob equivalent yield (4.17 t/ha). The lowest system cob

Table 5. Influence of liquid manures on yield of garden pea under sole and intercropping systems of baby corn and garden pea (pooled)

Treatments	Seed yield (q/ha)				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-
CS ₂	40.3	58.5	80.0	51.2	57.5
CS ₃	33.4	46.5	60.8	42.0	45.7
CS ₄	30.6	34.1	40.7	42.7	37.0
Mean	34.8	46.4	60.5	45.3	
	CS	M		CS × M	M × CS
S.Em ±	1.5	0.79		2.91	1.88
C.D. (P= 0.05)	5.9	2.4		4.9	6.8
Treatments	Green pod yield (q/ha)				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	-	-	-	-	-
CS ₂	73.3	106.3	145.5	93.1	104.5
CS ₃	30.4	42.3	55.3	38.2	41.5
CS ₄	18.6	20.7	24.6	25.9	22.4
Mean	40.7	56.4	75.1	52.4	
	CS	M		CS × M	M × CS
S.Em ±	1.86	0.74		3.73	2.17
C.D. (P= 0.05)	7.5	2.2		4.80	8.1

equivalent yield was noted from sole baby corn grown without liquid manure (CS₁M₁).

Land equivalent ratio (LER) showed that all the intercropping systems were advantageous over sole cropping. However, the highest LER was observed in the intercropping system of baby corn and garden pea (1:1) grown using Kunapajala (CS₃M₃) (1.60), indicating a 60% yield advantage, closely followed by the intercropping system of baby corn and garden pea (1:1) grown using Panchagavya (CS₃M₄) (Table 6).

Production economics: Production economics revealed that among different cropping systems and liquid manure combinations, the maximum cost of cultivation was incurred by the intercropping system of baby corn and garden pea (1:1) grown using Panchagavya (CS₃M₄) (₹111053/ha), closely followed by the intercropping system of baby corn and garden pea (1:1) grown

Table 6. Influence of liquid manures on system cob equivalent yield and land equivalent ratio of different cropping systems of baby corn and garden pea (pooled)

Treatments	System cob equivalent yield (t/ha)				
	M ₁	M ₂	M ₃	M ₄	Mean
CS ₁	1.45	1.59	1.72	1.53	1.57
CS ₂	2.75	3.99	5.46	3.49	3.92
CS ₃	2.70	3.22	4.17	3.11	3.30
CS ₄	2.26	2.38	2.69	2.55	2.47
Mean	2.29	2.79	3.51	2.67	
	CS	M		CS × M	M × CS
S.Em ±	0.07	0.02		0.14	0.08
C.D. (P= 0.05)	0.25	0.07		0.16	0.28
Treatments	Land equivalent ratio (LER)				
	LER of component crop a (baby corn)	LER of component crop b (garden pea)	Combined LER		
CS ₃ M ₁	1.07	0.41	1.49		
CS ₃ M ₂	1.03	0.40	1.42		
CS ₃ M ₃	1.22	0.38	1.60		
CS ₃ M ₄	1.10	0.41	1.51		
CS ₄ M ₁	1.08	0.25	1.33		
CS ₄ M ₂	1.01	0.19	1.21		
CS ₄ M ₃	1.03	0.17	1.20		
CS ₄ M ₄	1.03	0.28	1.31		

Table 7. Production economics of baby corn and garden pea under sole and intercropping systems (pooled)

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C
CS ₁ M ₁	86842	232000	145158	2.67
CS ₁ M ₂	105165	254400	149235	2.42
CS ₁ M ₃	109189	275200	166011	2.52
CS ₁ M ₄	110253	244800	134547	2.22
CS ₂ M ₁	79442	440029	360587	5.54
CS ₂ M ₂	97765	637802	540037	6.52
CS ₂ M ₃	101789	872828	771039	8.57
CS ₂ M ₄	102853	558515	455662	5.43
CS ₃ M ₁	87642	431298	343656	4.92
CS ₃ M ₂	105965	514707	408742	4.86
CS ₃ M ₃	109989	666498	556509	6.06
CS ₃ M ₄	111053	497903	386850	4.48
CS ₄ M ₁	87482	360907	273425	4.13
CS ₄ M ₂	105805	381503	275698	3.61
CS ₄ M ₃	109829	431046	321217	3.92
CS ₄ M ₄	110893	407953	297060	3.68

1 kg baby corn price: ₹160/kg, 1 kg garden pea price: ₹60/kg

using Panchagavya (CS₄M₄), while the lowest cultivation cost was required in the sole garden pea grown without using liquid manures (CS₂M₁) (₹79442/ha). Regarding the gross and net return as well as B:C, maximum values were obtained from sole garden pea grown using Kunapajala (CS₂M₃), while the lowest returns and B:C were shown by sole baby corn grown without using liquid manures (CS₁M₁). Among the intercropping systems, the intercropping system of baby corn and garden pea (1:1) grown using Kunapajala (CS₃M₃) recorded the highest gross return (₹666498/ha), net return (₹556509/ha), and B:C (6.06) (Table 7).

Discussion

The lowest growth attributes were obtained under sole baby corn as cereal crop baby corn was nutrient-exhaustive crop. When it was grown with garden pea in an intercropping system, it received nitrogen fixed by legume crop garden pea through a symbiotic relationship between rhizobium and root nodules. Compared to the 2:1 system of baby corn and garden pea intercropping, the 1:1 system of baby corn and garden pea intercropping was more beneficial for baby corn due to less competition among the baby corn plants for the biologically fixed nitrogen in the soil. In the case of garden pea, sole cropping performed best as it got fully benefitted by its biologically fixed nitrogen. Earlier, a similar result was reported by Biswas *et al.* (2020) in the oat + lathyrus intercropping system. Regarding liquid manures, the result might be due to the fact that plants responded positively to different liquid manures for their uptake, which in turn positively influenced the cell division, multiplication, etc., resulting in the development of meristematic tissues and shoot elongation as well as generation of leaves (Biswas *et al.*, 2019). Initially, growth attributes' increments were higher, which slowed down gradually. It was perhaps due to the partitioning and translocation of most of the dry matter towards reproductive parts in later stages. Control (no liquid manure application) recorded the lowest growth attributes of both the crops at all observation intervals as it did not receive the benefits of liquid organic manures.

The influence of biological nitrogen fixation as well as liquid manures was directly reflected in yield attributes and yield of

both the crops. Greater root growth as well as uptake of nutrients, especially nitrogen, might improve chlorophyll content for higher photosynthetic efficiency, resulting in high dry matter production and translocation of dry matter from vegetative (source) to reproductive parts (sink) (Biswas *et al.*, 2020). Liquid organic manures (especially Kunapajala) were sources of multiple nutrients and possibly rich in phytohormones, various enzymes, microorganisms, etc. In a study, Martinez (2008) also noticed that Kunapajala was rich in carbohydrates, proteins, alkaloids, ample amounts of phosphorus, triacylglycerides, esters, sterol esters, phospholipids, vitamins A, D, and E, etc., and microorganisms like *Rhizobium*, *Azotobacter*, *Azospirillum*, PSB, *Trichoderma*, and *Pseudomonas*. Along with the liquid organic formulations, FYM applied additionally at basal might help in the early decomposition and quick release of nutrients at the initial growth of the plants, which promoted photosynthesis and further partition of dry matter for reproductive part development (Mishra, 2014). Mishra (2007) obtained higher plant growth, grains/panicle, panicle length, etc., by applying Kunapajala at 10-days intervals on rice.

The system cob equivalent yield also got similarly influenced by the cropping system and liquid manure spray. Since the market price and yield of legumes are high, sole cropping of garden pea ensured a higher system cob equivalent yield. However, when the intercropping system of cereal + legume was considered, the better influence of biological nitrogen fixation on both the crops as well as the positive role of Kunapajala significantly improved system cob equivalent yield. The highest yield advantage, as estimated through the land equivalent ratio (LER), further confirmed the efficacy of 1:1 system of baby corn and garden pea intercropping when it was grown using Kunapajala spray.

Regarding production economics, the cost of cultivation was lower under manure application as the cost of preparation and application of liquid manures was not involved there. Among different intercropping systems, maximum returns and B:C were noted from the 1:1 system of baby corn and garden pea intercropping grown using Kunapajala, which might be the reflection of yield of both the crops.

Based on the findings from the investigation, it can be concluded that baby corn achieved the best growth and productivity when Kunapajala was applied in the intercropping system of baby corn and garden pea (1:1). In garden pea, the best growth and yield were observed when Kunapajala was applied in the sole cropping system of garden pea, closely followed by Kunapajala sprayed in the intercropping system of baby corn and garden pea (1:1). Considering the performance of both the crop as well as production economics, the intercropping system of baby corn and

garden pea (1:1) along with the application of Kunapajala @ 10 % at 15, 30, and 45 DAS can be recommended for cultivation in the eastern plateau and hill zone of India. Future studies can examine the long-term soil health benefits, optimize rates of application, extend models of intercropping, evaluate climate resilience, assess regional economic viability, and establish connections with markets for organic produce.

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