Original Research Article

PRODUCTIVITY AND PROFITABILITY OF CROPPING SYSTEM AND ROW RATIO ON THE PERFORMANCE OF CHICKPEA (*Cicer arietinum* L.) + LINSEED (*Linum usitatissimum* L.) INTERCROPPING

ABSTARCT

The experiment was conducted at crop research centre of SVPUA&T, meerut (U.P.) on sandy clay loam soil with proper drainage, low levels of available nitrogen and organic carbon, medium levels of phosphorus, potassium, sulphur, and pH that were moderately alkaline, during 2021-22. The experiment comprised Chickpea and linseed variety Avrodhi and Garima was tested in a split plot design with three replications and 16 treatment combinations consisting 4 intercropping and 4 cropping modules. *viz*., chickpea sole, linseed sole, chickpea + linseed in ratio of 1:1, chickpea + linseed in ratio of 2:1 and 4 cropping module *viz*., control without application of any kind of nutrient, inorganic module with the recommended dose of fertiliser, organic module with FYM, Tricoderma, seed inoculation by Rhizobium, and PSB, and natural module with seed treatment beejamruith, foliar application of jeewamruith, and soil application of panchgavya. Among all these treatments the combinations of 2:1 Chickpea + Linseed intercropping with inorganic perform better over the rest of the combinations.

Keyword: Chickpea, Linseed, Inorganic module, Organic module, Natural module, Intercropping.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a crucial pulse crop of the semi-arid tropics, with in the rainfed ecology of India. Globally, it's the third most significant pulse crop after dry beans (*Phaseolus vulgareris*) and dry peas (*Pisum sativum* L.). Zinc (340 mg $100g^{-1}$), calcium (190 mg $100g^{-1}$), magnesium (140 mg $100g^{-1}$), iron (7 mg 100g-1), and phosphorus (340 mg $100g^{-1}$) are all abundant in chickpea as well as it also contains 18–22% protein, 52–70% carbs, 4–10% lipids, 6% crude fibre, and ash. Chickpea is grown on an average of 14.84 M ha area around the world with the production of 15.08 MT and productivity 10.16 q ha^{-1} **(FAOSTAT, 2020),** In India, it is grown on 9.63 M ha area, with 11.91 MT production and 10.41 q ha^{-1} productivity (DoA, C&FW 2020-21). Among the states, Uttar Pradesh has 4th position (after Madhya Pradesh, Rajasthan, and Maharashtra), with an area of 0.57 million hectares and production of 0.53 MT, average productivity 930 kg ha^{-1} **(Agriculture Statistics at a Glance, GoI 2021).** Linseed (*Linum usitatissium* L.) is grown for seed and fiber. In India, it's mainly grown for seed to extract oil. It contains 20-24% protein and 37-42% oil, Within the world, linseed is cultivated on 3.54 M ha area, 3.37 MT production, and a median yield of 9.51 q ha^{-1} (FAOSTAT 2020), In India linseed is cultivated on area of 0.298 M ha, production 0.11 MT, and 5.47 q ha^{-1} Productivity **(DoA, C&FW 2020-21),** In Uttar Pradesh, it's cultivated on 0.18 M ha area, 0.12 MT production, and productivity is 671 kg ha^{-1} **(Ministry of Agriculture, GoI 2020)**, In 2014, linseed was approved by Health Canada for a health claim linking the consumption of whole flaxseed to lowered blood cholesterol levels, a serious risk factor for cardiovascular disease. Chickpea + linseed is one the foremost important cropping systems of India, Intercropping is additionally a component of intensive cropping, which is geared toward crop intensification. The good thing about this technique is geared toward maximum utilization of natural resources like rainfall, radiation, irrigation, and soil for higher crop production. In an intercropping system, nutrient supplement to plant plays a key role to increase crop yields.

MATERIALS AND METHODS

An experiment was conducted at CRC farm of the Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) located in Indo-Gangetic plains of Western Uttar Pradesh. Meerut lies on national highway 58 and is at a distance of 70 km from Delhi. The soil of experimental site was sandy clay loam in texture, low in available nitrogen and organic carbon, medium in available phosphorus and potassium and slightly alkaline pH. The experiment was carried out with 16 treatments consisting combination of 4 intercropping *viz*., chickpea sole, linseed sole, chickpea + linseed ratio 1:1, chickpea + linseed ratio 2:1 and 4 cropping module *viz*., control, inorganic module with recommended dose of fertilizer, organic module with FYM, *Tricoderma*, seed inoculation by *Rhizobium*, PSB and natural module with seed treatment by beejamruith, jeewamruith by foliar application, panchgavya by soil application, were tested in split plot design with 3 replications. Chickpea was taken as a base crop with plating geometry 30 cm × 15 cm. prior to 12 hours of sowing; seed were treated *Rhizobium* inculcation in chickpea. The recommended dose of fertilizer for chickpea 18:40:20:20 kg of N, P_2O_5, K_2O S per hectare and in linseed 120:40:20:20 kg of N, P_2O_5, K_2O S per hectare. Farm yard manure was applied wherever needed as per treatment combinations. *Tricoderma* fungus applied with FYM and broadcasted in the treatment plots where ever needed. Panchgavya was given in to two doses first was at the time of field preparing and second with irrigation water. Jeewamrutha was given in four doses, 1st dose was given at the time of sowing and then after 21 days interval as a foliar sprays (10%) in the field. Beejamrutha was used as seed treatment of chickpea and linseed. For linseed seed, seed was coat with beejamrutha, mixing by hand, dry well and then sown on filed, but for chickpea, seeds just dip quickly and then dry in shade and then sown on field. Economic of the treatments was computed on the basis of prevailing market price of input and output under each treatment. Data analysis was done as per the standard analysis of variance technique for the experimental designs following SPSS software based programme, and the treatment means were compared at $P< 0.05$ level of probability.

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3 RESULTS AND DISCUSSION

3.1 Grain/Seed yield (kg ha^{-1}) The data presented in table regarding grain yield of chickpea and seed yield of linseed presented in (Table-1) revealed that the in chickpea grain yield was influenced significantly by the intercropping and cropping modules. Chickpea sole recorded the highest grain yield (1432 kg ha$_{-1}$), which was significantly higher than both intercropping treatments. Among the both intercropping treatments ratio of 2:1 chickpea + linseed produced significantly higher grain yield (1165 kg ha$_{-1}$) than the ratio of 1:1 chickpea + linseed (479 kg ha$_{-1}$). In comparison with sole chickpea the intercropping of chickpea + linseed reduced 66 % and 22 % lower yield by 1:1 and 2:1 row ratio, respectively. Seed yield of linseed revealed that the seed yield was influenced significantly by the intercropping and cropping modules. Linseed sole recorded the highest seed yield (1419 kg ha$_{-1}$), which was significantly higher with both intercropping treatments. Among the both intercropping treatments ratio of 1:1 chickpea + linseed produced significantly higher seed yield (1233 kg ha$_{-1}$) than ratio of 2:1 chickpea + linseed (755 kg ha$_{-1}$). In comparison with sole linseed the intercropping of chickpea + linseed reduced 13 % and 46 % lower yield in 1:1 and 2:1 row ratio, respectively. This agreement with the findings of **Kumar and Nandan (2007remove space)**, Tanwar ***et al.* (2011), Upadhyay *et al.* (2012) and Bradar *et al.* (2015), Singh and Aulakh (2017).**

Among the cropping modules in chickpea the highest grain yield was recorded in inorganic cropping module (1004 kg ha$_{-1}$), which was significantly higher than the organic (853 kg ha$_{-1}$) and natural module (787 kg ha$_{-1}$). Whereas the lowest yield was recorded by control (433 kg ha_{-1}). On an average 131 %, 96 % and 81 % increase in chickpea yield over control in inorganic, organic and natural module, respectively. Chickpea + linseed 2:1 ratio having less competition for light, space and nutrient between both of the crop so chickpea grows well in 2:1 ratio as compare to 1:1 row ratio and recorded more yield. In linseed highest seed yield was recorded in inorganic cropping module (1057 kg ha_{-1}) which was significantly higher than the organic module (975 kg ha_{-1}) and natural module (794 kg ha_{-1}). Whereas the lowest seed yield was recorded by control (582 kg ha_{-1}). On an average 81%, 67% and 36 % increase in yield over control in inorganic, organic and natural module, respectively. These finding was also reported by **Tripathi *et al*. (2010) Abraham *et al.* (2011), Upadhyay *et al*. (2012), Singh *et al*. (2018), Gupta *et al*. (2019).**

3.2 Stover yield (kg ha^{-1}) The data presented in (Table-1) revealed that the stover yield was influenced significantly by the intercropping and cropping modules. Chickpea sole recorded the higher stover yield (2840 kg ha^{-1}), which was significantly higher than both intercropping treatments. Among the both intercropping treatments ratio of 2:1 chickpea + linseed produced significantly higher stover yield (2539 kg ha^{-1}) than ratio of 1:1 chickpea + linseed (1080 kg ha^{-1}). In comparison with sole chickpea the intercropping of chickpea + linseed reduced 61 % and 10 % lower stover yield in 1:1 and 2:1 row ratio, respectively. Stover yield of linseed was influenced significantly by the intercropping and cropping modules. Linseed sole recorded the highest stover yield (4064 kg ha^{-1}), which was significantly at par with chickpea + linseed 1:1 (3997 kg ha^{-1}) and the lowest stover yield were recorded in chickpea + linseed 2:1 (2484 kg ha^{-1}). In comparison with sole linseed the intercropping of chickpea + linseed 2 % and 39 % lower stover yield in 1:1 and 2:1 row ratio, respectively. Similar findings were given by **Tripathi *et al.* (2005), Wasu *et al.* (2013), Lal *et al*. (2017).** Among the cropping modules the highest stover yield in chickpea recorded in inorganic cropping module (2046 kg ha^{-1}), which was significantly higher than the organic (1786 kg ha^{-1}) and natural module (1663 kg ha^{-1}). Whereas the lowest stover yield was recorded by control (963 kg ha^{-1}). On an average 113 % and 72 % increase in chickpea stover yield over control in inorganic, organic and natural module, respectively. In linseed the highest stover yield was recorded in inorganic cropping module (2904 kg ha^{-1}) which was significantly at par with the organic module (2839 kg ha^{-1}). Whereas the lowest stover yield was recorded by control (2110 kg ha^{-1}). On an average 37%, 34% and 24 % increase in stover yield over control in inorganic, organic and natural module, respectively. Similar result was also found by **Ahmed *et al*. (2007), Ravi Kumar (2009), Hanumantappa *et al*. (2015), Jagadeesha *et al*. (2019).**

3.3 Biological yield (kg ha^{-1}) The data presented in (Table-1) revealed that the stover yield was influenced significantly by the intercropping and cropping modules. Chickpea sole recorded the higher stover yield (2840 kg ha^{-1}), which was significantly higher than both intercropping treatments. Among the both intercropping treatments ratio of 2:1 chickpea + linseed produced significantly higher stover yield (2539 kg ha^{-1}) than ratio of 1:1 chickpea + linseed (1080 kg ha^{-1}). In comparison with sole chickpea the intercropping of chickpea + linseed reduced 61 % and 10 % lower stover yield in 1:1 and 2:1 row ratio, respectively. In linseed biological yield was influenced significantly by the intercropping and cropping modules. Linseed sole recorded the highest biological yield (5416 kg ha^{-1}), which was significantly at par with the chickpea + linseed 1:1 (5298 kg ha^{-1}) and the lowest biological yield were record chickpea + linseed 2:1 (3239 kg ha^{-1}). In comparison with sole linseed the intercropping of chickpea + linseed 2 % and 40 % lower biological yield in 1:1 and 2:1 row ratio, respectively. **Tripathi *et al.* (2005), Kumar and Singh (2006).** Among the cropping modules the biological yield of chickpea recorded highest in inorganic cropping module (3896 kg ha^{-1}) which was significantly at par with the organic (3879 kg ha^{-1}) and in natural module (3487 kg ha^{-1}). Whereas the lowest biological yield was recorded by control (2692 kg ha^{-1}). On an average 45%, 44%

and 29 % increase in biological yield over control in inorganic, organic and natural module, respectively. In linseed the highest stover yield recorded in inorganic cropping module (2046 kg ha^{-1}), which was significantly higher than the organic (1786 kg ha^{-1}) and natural module (1663 kg ha^{-1}). Whereas the lowest stover yield was recorded by control (963 kg ha^{-1}). On an average 113 % and 72 % increase in chickpea stover yield over control in inorganic, organic and natural module, respectively. **Sune *et al*. (2006) Kumar and Yadav (2007), Gokhale *et al*. (2008), Meena *et al*. (2011).**

3.4 Harvest Index (%) The data presented in (Table-1) revealed that the harvest index was influenced significantly by the intercropping and cropping modules. Chickpea sole was recorded the highest harvest index (33.44 %), which was significantly higher with both intercropping treatments. Among the both intercropping treatments ratio of 2:1 chickpea + linseed (31.19 %) significantly at par with the ratio of 1:1 chickpea + linseed (30.19 %). In linseed, sole recorded highest harvest index (26 %) which was significantly higher with both intercropping treatments. Among the both intercropping treatments ratio of chickpea + linseed 1:1 (23 %) significantly at par with chickpea + linseed 2:1 (23 %). **Singh and Aulakh (2017), Singh *et al*. (2018).** Among the cropping modules harvest index was non-significant in respect of chickpea. Linseed recorded the highest harvest index recorded in inorganic cropping module (20 %) which was significantly at par with the organic module (19%) and in natural module (17 %) harvest index was record. Whereas the lowest harvest index was recorded by control (16 %). Similar result was find by **Ahmed *et al*. (2007), Ravi Kumar (2009).**

Table 1. Effect of intercropping cropping module on grain yield stover yield biological yield and harvest index of chickpea and linseed.

Treatments	**Chickpea**				**Linseed**			
	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index
Intercropping system								
Sole Chickpea	1432	2840	4272	33.44	-	-	-	-
Sole Linseed	-	-	-	-	1419	4064	5416	26.00
Chickpea + Linseed 1:1	479	1080	1559	30.19	1233	3997	5298	23.00
Chickpea + Linseed 2:1	1165	2539	3704	31.19	755	2484	3239	23.08
SEm±	*16.35*	*32.32*	*48.66*	*0.47*	*19.18*	*56.78*	*75.37*	*0.34*
CD (P=0.05)	***56.57***	***111.84***	***168.37***	***1.64***	***66.36***	***196.47***	***260.81***	***1.16***
Cropping system modules								
Control	433	963	1396	22.63	582	2110	2692	16.21
Inorganic module	1004	2046	3050	24.53	1057	2904	3896	20.25
Organic module	853	1786	2638	23.97	975	2839	3879	18.75
Natural module	787	1663	2450	23.69	794	2692	3487	16.88
SEm±	*17.00*	*35.43*	*52.41*	*0.53*	*20.66*	*56.70*	*74.61*	*0.54*

CD (P=0.05)	***49.61***	***103.42***	***152.98***	***NS***	***56.70***	***165.51***	***217.76***	***1.59***

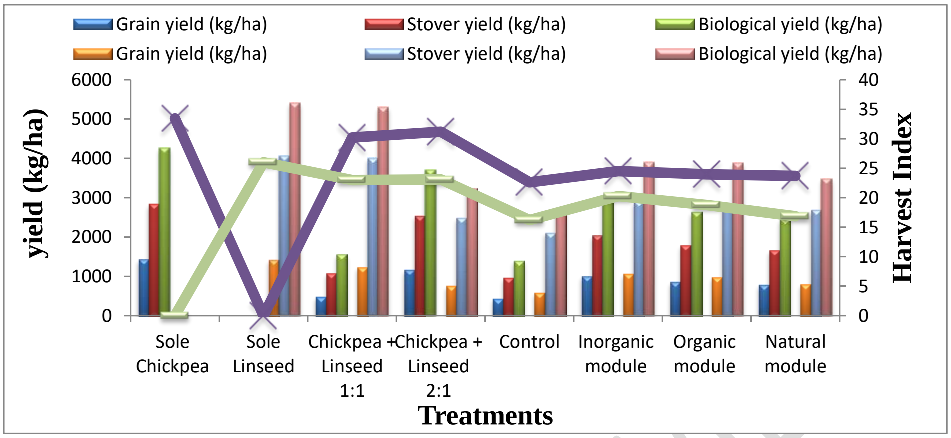

Fig. 1 Effect of intercropping and cropping module on grain yield stover yield biological yield and harvest index of chickpea and linseed.

3.4 Chickpea equivalent yield (kg ha^{-1}) The data on CEY presented in (Table-2) revealed that the Chickpea equivalent yield (CEY) Influenced significantly by the intercropping and cropping modules. The highest chickpea equivalent yield (1974 kg ha^{-1}) was recorded with intercropping chickpea + Linseed 2:1 and it is followed by 1:1 row ratio (1800 1974 kg ha^{-1}). Among the cropping modules the highest chickpea equivalent yield was recorded in inorganic cropping module (2105 kg ha^{-1}) which was followed by organic module (1868 kg ha^{-1}) and natural module (1612 kg ha^{-1}). Whereas the lowest chickpea equivalent yield was obtained under control (1040 kg ha^{-1}). **Ahlawat *et al*. (2005), Biradar *et al*. (2015).**

Table 2: Effect of intercropping and cropping module on CEY and LER

Treatment	**Chickpea equivalent yield (CEY)** (kg ha^{-1})	**Land equivalent ratio (LER)**
Intercropping system		
Sole Chickpea	1432	1.00
Sole Linseed	1419	1.00
Chickpea + Linseed 1:1	1800	1.17
Chickpea + Linseed 2:1	1974	1.32
SEm±	*29.15*	*0.02*
CD (P=0.05)	***100.86***	***0.07***
Cropping system modules		
Control	1040	1.05
Inorganic module	2105	1.25
Organic module	1868	1.15
Natural module	1612	1.04
SEm±	*33.79*	*0.02*
CD (P=0.05)	***98.62***	***0.06***

3.5 Land equivalent ratio (LER) The data on LER given in (Table-2) revealed that influenced significantly by the intercropping and cropping modules. The maximum LER (1.32) was recorded under 2:1 row ratio which was significantly superior over other treatments and followed by 1:1 row ratio (1.17). Among the cropping modules the highest land equivalent ratio (1.25) recorded in inorganic cropping modules. This was followed by organic module (1.15) whereas the minimum land equivalent ratio was obtained under control. Similar results were also reported **by Ahlawat *et al*. (2005), Kumar and Singh (2006) and Arya *et al.* (2007).**

3.6 Cost of cultivation (Rs ha^{-1}) The data presented in (Table-3) revealed that Cost of cultivation influence significantly by the intercropping and cropping modules. The highest cost of cultivation (38580.75 Rs ha^{-1}) was recorded with sole chickpea which was significantly at par with the chickpea + linseed 1:1 (36978.25 Rs ha^{-1}) and chickpea + linseed 2:1 (38329.50 Rs ha^{-1}) intercropping system whereas the lowest cost of cultivation was recorded with sole linseed (30853 Rs ha^{-1}).Among the cropping modules the highest cost of cultivation (39117.75 Rs ha^{-1}) was recorded with inorganic module which was significantly at par with organic module (38680.50 Rs ha^{-1}). The lowest cost of cultivation was recorded by the control (31731.75 Rsha^{-1}).

3.7 Gross return (Rs ha^{-1}) The data given in (Table-3) revealed The highest gross returns was recorded with chickpea + linseed 2:1 intercropping (117431.48 Rs ha^{-1}) system whereas the lowest gross returns was recorded with sole chickpea (83415 Rs ha^{-1}). Among the cropping modules the highest gross return (125380.03 Rs ha^{-1}) was recorded with inorganic module whereas the lowest gross return was recorded under control (63329.50 Rs ha^{-1}).

Table 3: Effect of intercropping system and cropping system module on cost of cultivation (Rs ha^{-1}), gross returns (Rs ha^{-1}), net return (Rs ha^{-1}), B:C ratio of chickpea and linseed.

Treatment	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C
Intercropping system				
Sole Chickpea	38580.75	83415.14	44834.39	2.15
Sole Linseed	30853.25	89429.29	58576.04	2.87
Chickpea + Linseed 1:1	36978.25	106687.91	69709.66	2.83
Chickpea + Linseed 2:1	38329.50	117431.48	79101.98	3.02
SEm±	*686.20*	*2404.55*	*1607.96*	*0.05*
CD (P=0.05)	***2374.56***	***8320.85***	***5564.26***	***0.17***
Cropping system modules				
Control	31731.75	63329.50	31597.75	2.01

Inorganic module	39117.75	125380.03	86262.28	3.21
Organic module	38680.50	111580.02	72899.52	2.89
Natural module	35211.75	96674.28	61462.53	2.76
SEm±	*681.14*	*1666.31*	*1171.14*	*0.05*
CD (P=0.05)	***1988.12***	***4863.61***	***3418.33***	***0.15***

3.8 Net return (Rs ha^{-1}) The data on net return (Table-3) recorded with chickpea + linseed 2:1 (79101.98 Rs ha^{-1}) intercropping system whereas the lowest net returns was recorded with sole chickpea (44834.39 Rs ha^{-1}). Among the cropping modules the highest net returns (Rs 86262.28ha^{-1}) was recorded with inorganic module whereas the lowest net returns was recorded under control (31597.75 Rs ha^{-1}). **Kumar and Singh (2006), Sharma and Goswami (2010), Ogola *et al*. (2013), Kalaghatagi et al. (2017).**
3.9 B:C ratio Benefit cost represented in (Table-3) the highest benefit cost ratio was recorded with chickpea + linseed 2:1 (3.02) intercropping system whereas the lowest benefit cost ratio was recorded with sole chickpea (2.15). Among the cropping modules the highest benefit cost ratio (3.21) was recorded with inorganic module whereas the lowest benefit cost ratio was recorded under control (2.01). These findings are in close agreement with the results of Prasad *et al.* (2006) and Ahlawat *et al.* (2005). **Kumar and Sharma (2006), Kumar and Nandan (2007), Abraham *et al*. (2010), Ahlawat and Gangaiah (2010).**

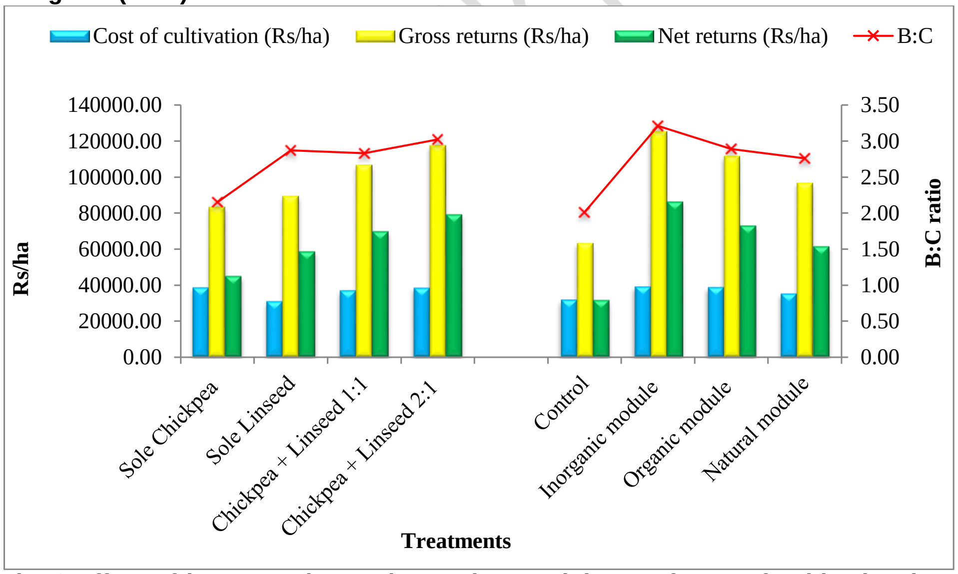

Fig. 2 Effect of intercropping and cropping module on of cost of cultivation (Rs ha^{-1}), gross returns (Rs ha^{-1}), net return (Rs ha^{-1}), B:C ratio of chickpea and linseed.

4. CONCLUSION

On the basis of foregoing findings, it remains no more obscure that chickpea and linseed both performed individually better in sole stand. Among the intercropping and cropping module, 2:1 ratio of chickpea + linseed intercropping with inorganic module can perform better to obtain higher productivity, equivalent yield and profit. Whereas organic or natural module is beneficial to sustain the soil health.

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