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Intercropping of linseed (*Linum usitatissimum*) and lathyrus (*Lathyrus sativus*) as influenced by moisture conservation practice in rice fallow

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ABSTRACT

A field experiment was conducted at Assam Agricultural University, Jorhat, during the *rabi* season of 2021-2022 to evaluate a suitable linseed and lathyrus intercropping system (s) in rice fallow and to evaluate the effect of mulching with paddy straw on growth and yield of linseed and lathyrus intercropping system. The treatments were laid out in a factorial randomized block design with three replications. The experiment consisted of two factors, viz. mulching and cropping systems. There were two levels of mulching viz. no mulching (M_0) and mulching @ 2 tons/ha (M_1) of paddy straw and five levels of cropping systems viz. sole linseed (C_1), sole lathyrus (C_2) linseed: lathyrus 1:1 ratio (C_3), linseed: lathyrus 2:1 ratio (C_4) and linseed:lathyrus 3:1 ratio (C_5). Mulching with paddy straw @ 2 tons per hectare resulted in a significant increase in the growth and yield attributing parameters of both linseed and lathyrus. Among the cropping systems, the highest growth and yield parameters of linseed were obtained from linseed: lathyrus 1:1 row ratio succeeded by 2:1 and 3:1. Linseed had shown better performance when intercropped with lathyrus as compared to sole crop. However, lathyrus could perform best under sole cropping compared to intercropping systems since linseed offered competition to lathyrus. The highest relative crowding coefficient and land equivalent ratio was obtained from linseed: lathyrus 1:1 ratio followed by 2:1 and 3:1. Linseed+lathyrus 1:1 row ratio also resulted in the highest linseed equivalent yield among all the intercropping systems.

Key words: *Intercropping; Lathyrus, Linseed, Paddy straw mulch*

Introduction

Assam is a region where the majority of the cultivated land is covered with rice. Among the different types of rice, winter rice or *kharif* rice is widely cultivated here. However, it has been noticed that after harvesting the winter rice, these pieces of land mostly remain fallow or uncultivated during the *rabi* season due to unfavourable land conditions and limited moisture availability. Therefore, there lies a great possibility of utilizing rice fallow lands by means of growing different pulse crops like lathyrus, lentil, pea, etc., intercropped with oilseed crops like linseed, rapeseed, etc. Oilseeds and pulse crops are important commercial crops and are an integral part of our diet. Linseed (*Linum usitatissimum*) commonly known as flax seed is an important oilseed crop cultivated in Assam. It is a dual-purpose crop that is capable of producing both fibre and oil. Linseed oil is a rich source of omega-3 fatty acids and has been shown to cure inflammation, rheumatoid arthritis, etc. It has also been shown to reduce blood pressure and improve heart health. Being a cool season crop, linseed can be eas-

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ily grown after winter rice in the cropping system of Assam and high yields can be obtained even under a poor management system. Lathyrus *(Lathyrus sativus*), on the other hand, is an important pulse crop grown in Assam, mostly under a relay cropping system with rice. Lathyrus is popularly known as *khesari* dal or grass pea. Pulses are a great source of plant-based protein and hence have a huge demand in the market. Also being a legume crop, they further improvise the cropping system by fixing atmospheric nitrogen.

The given experiment was conducted while keeping in mind the importance of oilseeds and pulse crops and with the aim of utilizing rice fallow lands to maximize the productivity and income of farmers.

Materials and Methods

The experiment was conducted during *the rabi* season of 2021-2022. The soil of the experimental site was sandy loam in texture and acidic in reaction (pH 5.43). It was medium in organic carbon (0.63%), low in available nitrogen (197.12 kg/ha), medium in available phosphorus (25.86 P_2O_5 kg/ha), and medium in available potassium (180.57 K_2O kg/ha). The total rainfall received was recorded to be 187.6 mm with a total 14 number of rainy days, out of which four rainy days with 76.7 mm of rainfall was received during the last week of maturity (i.e., near harvest). The mean evaporation ranged from 1.2-2.9 mm.

Treatments consisted of two mulching treatments *viz*. no mulching(M_0) and mulching with paddy straw @ 2 tons/ha (M_1) and five cropping systems *viz*. sole linseed (C_1), sole lathyrus (C_2), linseed: lathyrus 1:1 ratio (C_3), linseed:lathyrus 2:1 ratio (C_4) and linseed: lathyrus 3:1 ratio (C_5). All the treatments were laid out in a factorial randomized block design with three replications and ten treatments in each replication.

Both the crops were sown on 6th December 2021. Lathyrus was harvested 115 days after sowing whereas linseed was harvested 120 days after sowing. The varieties of linseed and lathyrus used in the experiment were "T-397" and "Prateek", respectively. Ten representative samples of each crop were collected from each plot to measure the growth and yield parameters. The seed and stover yield of each treatment was weighed and recorded separately after threshing and drying which was then used to calculate the biological efficiencies of the intercropping systems. The formula used to calculate linseed equivalent yield (LEY) is given below:

$$\text{Linseed equivalent yield (LEY)} = \frac{Yi \times Pi}{Pm}$$

Where,
Yi= Yield of intercrop (kg/ha)
Pi= Price of intercrop (Rs./kg)
Pm= Price of main crop (Rs./kg)

Results and Discussion

Effect of mulching

Paddy straw mulching @ 2 tons per hectare had significantly increased the plant height and yield attributing characters of both linseed and lathyrus. With the enhancement in yield attributing parameters, the seed yield of the crops also significantly increased on the application of mulch as compared to no mulch (Table 1 and 2). Sarangi *et al.* (2010) reported that paddy straw mulching resulted in a 7.2% increase in plant height and yield attributing characters like siliqua number per plant, number of seeds per siliqua, and seed yield also increased by 24.6%, 17.6%, and 35.4% respectively, over no mulching. Mulching acts as a physical barrier over the topsoil and thus it reduces the loss of water from the soil via evaporation. This particular phenomenon helps to conserve soil moisture and makes it more available to the crops. The enhancement in growth, as well as yield parameters of linseed and lathyrus upon application of mulch, might be because of this conservation of moisture. Along with the conservation of moisture, mulching could also conserve soil nutrients by minimizing their losses through volatilization and leaching. Mulching, however, is also known to regulate soil temperature and thus creates a congenial microclimate for the optimum growth of the crops. Another extremely important benefit offered by mulching is the suppression of weed density and biomass. Weeds compete with the main crop for water, nutrients, and other natural resources. With a reduction in weed density, the competition for these resources is reduced and hence they become easily available to the main crop. All of these benefits provided by mulching might have resulted in the magnification of growth and yield attributing characters of both linseed and lathyrus in the present experiment under study. Tetarwal *et al*.

(2015) from his experiment concluded that application of paddy straw mulch @ 10 tons per hectare in linseed resulted in significant increase in seed yield over no mulch. They also reported that compared to no mulch, mulching @ 10 tons/ha gave the highest consumptive use, moisture utilization rate and water use efficiency which increased by 28.0%, 27.4% and 22.0% respectively.

Effect of intercropping

Among the cropping systems, from Table 1, it is revealed that the plant height and yield parameters of linseed were found to be highest in linseed: lathyrus 1:1 row ratio. The plant height of linseed was significantly higher in linseed: lathyrus 1:1 and 2:1 ratio over sole cropping but plant height in 3:1 ratio was statistically at par with sole linseed. The number of capsules per plant and number of seeds per capsule of linseed was found to be highest in the 1:1 row ratio followed by 2:1 and 3:1. Sole linseed recorded the lowest number of capsules and seeds. Klimek *et al.* (2018) also found that intercropping of pea (legume) with linseed significantly increased the number of capsules and seeds per plant of linseed. The improvement in linseed when it was intercropped with lathyrus can be attributed to the fact that lathyrus as a legume crop is capable of fixing atmospheric nitrogen. Thus, lathyrus did not exhaust the soil nitrogen and rendered it more easily available to be consumed by linseed whose effect could be seen in the enhanced growth condition of linseed under intercropping with lathyrus. Another reason why linseed

Table 1. Plant height, yield attributing characters and seed yield of linseed as influenced by mulching and cropping systems

Treatments	Plant height (cm)	Number of capsules/plant	Number of seeds/capsule	Test weight (g)	Seed yield (kg/ha)
Mulching					
No mulch (M_0)	50.02	31.86	9.69	5.18	419.18
Mulching (M_1)	52.27	33.54	10.30	5.29	469.17
SEm (±)	0.29	0.38	0.15	0.11	2.96
C.D. (P=0.05)	0.89	1.16	0.45	NS	8.98
Cropping systems					
Sole linseed	49.51	31.08	9.44	5.05	499.03
Linseed: Lathyrus (1:1)	53.24	34.45	10.78	5.51	400.54
Linseed: Lathyrus (2:1)	51.80	32.74	10.11	5.23	429.44
Linseed: Lathyrus (3:1)	50.01	32.54	9.67	5.14	447.68
SEm (±)	0.42	0.54	0.21	0.16	4.19
C.D. (P=0.05)	1.26	1.64	0.64	NS	12.70
Interaction	NS	NS	NS	NS	NS

Table 2. Plant height, yield attributing characters and seed yield of lathyrus as influenced by mulching and cropping systems

Treatments	Plant height (cm)	Number of pods/ plant	Number of seeds/ pod	Test weight (g)	Seed yield (kg/ha)
No mulch (M_0)	26.24	4.89	4.39	58.74	219.13
Mulching (M_1)	31.01	5.36	4.81	60.07	269.22
SEm (±)	0.61	0.09	0.09	0.75	5.93
C.D. (P=0.05)	1.85	0.28	0.28	NS	18.00
Cropping systems					
Sole linseed	31.79	5.75	5.00	59.64	479.10
Linseed:Lathyrus (1:1)	28.11	5.24	4.56	59.54	233.97
Linseed:Lathyrus (2:1)	27.47	4.76	4.45	59.25	151.94
Linseed:Lathyrus (3:1)	27.13	4.74	4.39	59.20	111.70
SEm (±)	0.86	0.13	0.13	1.06	8.39
C.D. (P=0.05)	2.62	0.40	0.39	NS	25.45
Interaction	NS	NS	NS	NS	NS

Table 3. Relative crowding coefficient, aggressivity, land equivalent ratio and linseed equivalent yield (LEY) of the intercropping system

Treatments	Relative crowding coefficient		Product	Aggressivity		Land equivalent ratio (LER)		Total LER	Linseed equivalent yield (kg/ha)
	Kab (linseed)	Kba (lathyrus)	K	Linseed	Lathyrus	La (linseed)	Lb (lathyrus)	La+Lb	
Linseed:Lathyrus (1:1)	4.07	0.95	3.88	0.16	-0.16	1.07	0.37	1.44	556.52
Linseed:Lathyrus (2:1)	3.28	0.93	3.04	0.47	-0.47	1.15	0.24	1.39	530.73
Linseed:Lathyrus (3:1)	3.11	0.91	2.84	0.62	-0.62	1.20	0.18	1.37	522.15

was benefitted upon intercropping with lathyrus might be the spatial differences between the two crops. Linseed is taller than lathyrus which made it possible for linseed to intercept more light in intercropping as compared to sole crop, where all the crops were approximately of the same height which might have created hindrance to light interception. During intercropping of maize with black gram, Padhi *et al.* (2006) also reported that the 1:1 row ratio gave the highest productivity and profitability over 2:2 and 2:1 row ratios. Klimek *et al*. (2018) also found that intercropping pea with linseed had significantly increased the number of capsules and seeds per plant of linseed.

However, lathyrus was not benefitted from intercropping and performed best under sole cropping. The growth, as well as yield attributing characters of lathyrus, was highest in sole lathyrus followed by 1:1 and 2:1 row ratio. 3:1 row ratio recorded the poorest growth condition of lathyrus. This was probably because of the dominance of linseed over lathyrus as indicated by the aggressivity values (Table 3). Lathyrus suffered acute competition from linseed and thus produced less number of pods and seeds under intercropping as compared to the sole crop. Biswas *et al*. (2019) also reported that lathyrus performed better in sole cropping than intercropping with oat. The seed yield of both linseed and lathyrus was highest under sole cropping certainly because of its higher plant population as compared to intercropping.

Land equivalent ratio, relative crowding coefficient, aggressivity and linseed equivalent yield

Linseed+lathyrus in 1:1 ratio recorded the highest land equivalent ratio followed by 2:1 and 3:1 ratio. All the intercropping systems recorded LER values of more than 1 which indicated that under the same given area, intercropping had produced higher yields than sole crops. The relative crowding coefficient (RCC) of linseed in all the intercropping systems was found to be more than 1 while that of lathyrus was less than 1 which revealed that linseed had a yield advantage in intercropping over sole crop while lathyrus produced lesser yields in intercropping than sole crop. The RCC of linseed: lathyrus 1:1 ratio was highest followed by 2:1 and 3:1. The aggressivity value of linseed was found to be positive whereas that of lathyrus was negative in all the intercropping systems. This indicated that linseed was the dominant crop in the cropping mixture and lathyrus was dominated by linseed.

Conclusion

Intercropping of linseed + lathyrus in 1:1 ratio and application of paddy straw mulching @ 2 tons per hectare had significantly increased the yield attributes and seed yield of linseed. Although the lathyrus yield was lower than sole crop in 1:1 ratio, but the increased yield of linseed had compensated for this loss and thus, this system had produced the highest linseed equivalent yield (LEY) that would result in higher profitability. Thus, it can be concluded that intercropping of linseed and lathyrus in the ratio 1:1 combined with paddy straw mulching @ 2 tons per hectare can be followed for increasing the productivity of oilseeds and pulses in medium lowland rice fallow lands in Assam.

Since these results were based on one year experiment, further investigation is necessary to recommend it to the farming community of Assam.

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