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The performance of intercropping of rapeseed with pea grown on rice fallows

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Abstract
A field experiment was conducted at the ICR farm, Assam Agricultural University, Jorhat with a view to study the performance of intercropping of rapeseed with pea under different integrated nutrient management (INM) practices. The treatments comprised of four intercropping systems (C) *viz.*, C1 -Sole Rapeseed, C2- Rapeseed : Pea (1:2), C3-Rapeseed : Pea (2:1) and C4 –Rapeseed : Pea (2:2) and four levels of integrated nutrient management practices (M) *viz;*M1-100% RDF (Recommended Dose of Fertilizers), M2- 75% RDF+ 25% N through enriched compost, M3- 75% RDF+ 25% N through vermi-compost and M4- 50% RDF+ Bio-fertilizers + 50% N through vermi-compost. The treatments were laid out in a Factorial Randomized Block Design with three replications. The crops and varieties tested were Rapeseed -TS-67, Pea -Azad P-1. Intercropping of rapeseed + pea 2:2 or 2.1 and INM practices of 75% RDF + 25% N through vermicompost or 50% RDF + biofertilizers + 50% N through vermicompost, significantly increased the growth and yield attributes.

Keywords: intercropping, integrated nutrient management, rapeseed and pea

Introduction
Rapeseed is one of the important oil seed crop in India. It is grown in about 6.51 million ha with total production of about 7.67 million tones and an average productivity of 1,179 kg/ha (GoI, 2010-11) [4] it is also most important crop of Assam. The total cultivated area under this crop is 2.48 lakh ha, producing about 1.39 lakh tonnes of edible oil with an average productivity of 528 kg/ha in the state (DES, 2011) [2]. Similarly, pea is also one of the pulses which play an important role in meeting up in the requirement of pulses in Assam as well as in the country. Both these *rabi* crops are very much suited and have a greater possibility in increase the productivity of rice fallows, when balanced and adequate supply of nutrients are provided to the crops. In Assam growing rice is tradition and *kharif* rice is the principal crop of Assam which occupies about 18.59 lakh ha out of the total rice area of 25.71 lakh ha. However, in spite of recent development in agriculture, double or triple cropping in rice land has not yet got its way and more than 75 per cent of the total rice cropped area of Assam seems to be lying fallow.
Rice based cropping systems are most common and popular in Assam. Cultivation of rapeseed after kharif rice (rice fallows) and green gram as the third crop in summer season ie; rice-rapeseed- green gram in sequence is considered to be more productive and gaining popularity in Assam. Moreover, pea as *utera* crop in *kharif* rice has been introduced as a potential winter crop in the state. But the precise agronomy practices of intercropping rapeseed with pea in rice fallows have not yet been developed so far. However, research has been carried out to evaluate the responses of individual/component crops in determining the optimum dose of fertilizer, but information was very meager on growing such oil seeds and legumes as mixed or as intercrop. However, there are every possibility to achieve the yield potentialities of oil seeds and pulse like rapeseed and pea by growing them together as inter cropping even late, in rice fallows with the available resource base, like integrated nutrient management through inclusion of organic manures and bio-fertilizers. Consequently, beneficial effect of such management practices may result in increasing the yield of succeeding summer pulse like green gram. Thus, such crop intensification in rice fallows might have a better proposition not only on increasing the farm income but also will open avenues for employment generation.

Method and Materials
The experiment was carried out at the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat.

The farm is situated at 24°47' N latitude, 94°12' E longitude and at an altitude of 86.6 m above the mean sea level.The experimental treatments comprised of four intercropping systems (C) *viz.*, C 1 -Sole Rapeseed, C2- Rapeseed: Pea (1:2), C3-Rapeseed: Pea (2:1) and C4 -Rapeseed: Pea (2:2) and four levels of integrated nutrient management practices (M) *viz;*M1-100% RDF (Recommended Dose of Fertilizers), M2- 75% RDF+ 25% N through enriched compost, M3- 75% RDF+ 25% N through vermicompost and M4- 50% RDF+ Bio-fertilizers+ 50% N through vermicompost. These treatments were evaluated in Factorial Randomized Block Design (FRBD) having three replications. Five plants were randomly selected and tagged in each plot, dates of phenological event (Patel and Mehta 1987) [8] viz: growth and growth parameter yield and yield attributes, and others parameters such as quality attributes were recorded from each treatment. The rapseed variety TS 67 and pea variety Azad P-1 were sown 30 x 5-6 cm on dated 27th November and harvested after maturity age. According to various phenological events from emergence to maturity, whole life cycle of the crop was divided into vegetative flowering and siliqua formation phase, and entire growth period corresponding phases were summed up. All the data were tabulated and analysed statistically as per the procedure suggested by Panse and Sukhatme (1978) [7]. The 'F' (Fisher's) test was used for judging the significance of the treatment mean at 5 per cent probability level. Whenever 'F' test showed significant difference, the differences between treatments means were further tested using critical difference (CD) values.

Results and Discussion

The result and discussion of the preceding are hereby discussed briefly. An attempt has been made to interpret and explain the results with a view to understand the 'causes' and 'effect' relationship among growth and yield attributes of the rapeseed and pea crop observed according to intercropping systems at different row proportions and integrated nutrient management practices on both the crops. The dates of sowing brought significant variation on different agronomical parameters recorded at successive stages of rapeseed and pea *viz*. plant height (cm), 1000 seed weight (g), no. of leaves/plant, plant population /meter, no. of branches/plant, dry matter (g)/plant, No of Siliquae or Pods/ Plant, Length of Siliquae or Pods/ Plant and No of Seeds/Siliquae or Pods.

a.1 Effect of intercropping systems on growth and yield attributes of rapeseed

Data on plant height were recorded at three different stages viz; 30, 60 and 90days after sowing (DAS) and presented in Table-1. Results revealed that different intercropping systems did not influence the plat height significantly recorded at all the growth stages of the crop. However, comparatively higher plant heights at all the stages due to rapeseed + pea intercropping were observed than that of sole rapeseed. The number of leaves/plant recorded at 30 and 60 DAS due to different intercropping systems is presented in Table-2. It was observed that the number of leaves/plant at both the stages did not vary significantly due to different intercropping systems. However, intercropping of rapeseed + pea at 2: 2 ratios resulted in higher values of leaves/plant at both the stages over rest of the treatments. The plant population, number of branches/plant and dry matter/plant at harvest as influenced by different intercropping systems are presented in Table-2. Results revealed that plant population/m and dry matter/plant of rapeseed did not varied significantly. However, intercropping of rapeseed + pea at different row ratios produced comparatively higher values of dry matter/plant of rapeseed over that of sole crop. The number of branches/plant due to the intercropping systems of rapeseed + pea ratios 2:1 (6.22 branches/plant), 2:2 (6.12 branches/plant) and 1:2 (6.08 branches/plant) were statistically at par in their effect, and they were significantly superior to sole rapeseed (5.71 branches/plant). The data on yield attributing characters of rapeseed viz; number of siliqua/plant, length of siliqua, number of seeds/siliqua and 1000-seed weight of rapeseed as influenced by different intercropping systems are presented in Table-3 and Table-1. The intercropping rapeseed + pea ratio 2:2 produced significantly the highest number of siliqua/plant (42.49 siliqua/plant) over rest of the intercropping systems. This was followed by rapeseed + pea ratio 2:1 (39.76 siliqua/plant) and rapeseed + pea ratio 2:1 (38.68 siliqua/plant), both were statistically at par in their effect but, significantly superior to sole rapeseed (32.50 siliqua/plant). The effect of intercropping systems on length of siliqua/plant revealed that the variations due to rapeseed + pea ratios 2:2 (7.65cm), 1:2 (7.48cm) and 2:1 (7.44cm) were statistically similar and their values were significantly superior to sole rapeseed (6.88 cm). However, the variations resulting from different intercropping systems on number of seeds/siliqua and 1000-seed weight of rapeseed were not significant. Debbarma, 2007 reported that intercropping Rapeseed + French bean systems in different replacement series showed significantly higher results in terms of growth and yield parameters of the crops over their respective sole crops.

a.2 Effect of intercropping systems on growth and yield attributes of pea

The plant height of pea was observed that different rapeseed + pea intercropping systems did not influence significantly in all the periods of observations. However, number of leaves recorded at 60 DAS was significantly increased due to rapeseed + pea ratio 2: 2 (7.3 leaves/plant) compared to rapeseed + pea ratio 1: 2 (6.90 leaves/plant) and rapeseed + pea ratio 2: 1 (6.41 leaves/plant). The plant population /m and dry matter production/plant were not differed significantly due to different rapeseed + pea intercropping, but the number of branches/plant of pea due to rapeseed + pea ratio 2: 2 (4.62 branches/plant) increased significantly over that of rapeseed + pea ratio 1: 2 (4.24 branches/plant). However, the effect of rapeseed + pea ratio 2: 2 was at par with rapeseed + pea ratio 2: 1 (4.35 leaves/plant). The number of pods/plant (6.93 pods/plant), length of pod (6.10 cm) and seeds/pod (5.44 seeds/pod) of pea were increased significantly due to rapeseed + pea ratio 2: 2, and proved superior to rapeseed + pea ratio 1: 2. However, in these respects, the values resulted by rapeseed + pea ratio 1: 2 and rapeseed + pea ratio 2:1 were statistically similar in their effect. The 1000-seed weight of pea due to different rapeseed + pea ratios remained unaffected. Sachan and Uttam (1992) [9] reported that intercropping system increases growth and yield attributes like plant height, siliquae per plant, seeds per siliqua, seed weight per plant, number of pods per plant, number of grains per pod, grain weight per plant and 1000 -grain weight in mustard + gram intercropping system.

b.3 Effect of integrated nutrient management on growth and yield attributes of rapeseed

Data on plant height recorded at three different growth stage

of rape seed viz; 30, 60 and 90 DAS and number of leaves/plant recorded at 30 and 60 DAS. Results revealed that different integrated nutrient management (INM) practices did not influence significantly in all the observation. However, comparatively higher values of plant height and leaves/plant were observed under 50% RDF + biofertilizers + 50% N through vermicompost over 100 % RDF alone. The plant population/m, branches/plant and dry matter/plant of rapeseed recorded at harvest due to different INM practices. Results revealed that plant population/m did not differ significantly due the INM practices. The number of branches/plant under the INM practices of 75% RDF + 25% N through vermicompost (6.30 /plant), 50% RDF + biofertilizers + 50% N through vermicompost (6.13/plant) and 75% RDF + 25% N through EC(6.07/plant) were at par in their effects but they were significantly superior to 100 % RDF alone.(5.62/plant). In case of dry matter production of rapeseed also, all the INM practices produced statistically similar values which were significantly superior to 100 % RDF alone. The highest dry matter/plant was observed under 50% RDF + biofertilizers + 50% N through vermicompost (7.30 g/plant) and the lowest was under 100% RDF alone (6.64 g/plant). The data on yield attributing characters of rapeseed viz; number of siliquae/plant, length of siliqua, number of seeds/siliqua and 1000-seed weight of rapeseed as influenced by different INM practices. The effects of INM practices 75% RDF + 25% N through vermicompost (41.45/plant) and 75% RDF + 25% N through EC (39.37/plant) on resulting number of siliquae/plant were at par in their effect but, both were proved significantly superior to 100% RDF alone (33.89/plant). The effect of INM practices on length of siliqua revealed that 75% RDF +25% N through enriched compost (7.71 cm), 50% RDF + bio-fertilizers + 50% N through vermicompost (7.71 cm) and 75% RDF +25% N through vermicompost (7.39 cm) resulted in statistically similar values but were significantly superior to that of 100% RDF (6.63 cm). In regards to the number of seeds per siliqua, the effect of 75% RDF +25% N through EC (16.47 seeds/siliqua) or vermicompost (16.28 seeds/siliqua) were at par but their values were significantly higher as compared to 100% RDF (15.67 seeds/siliqua). However, 1000–seed weight due to different INM practices did not vary significantly. Fertilizer application has been a major strategy for soil nutrient replenishment. On the other hand, use of organic materials not only increase the nutrient status of the agricultural soils but also help to improve various physical, chemical and biological properties of soils leading to betterment of soil quality and also to increased fertilizer use efficiency (Dick and Gregorich, 2004) [3]. Therefore, a substitution and/or supplementation of major nutrients with a considerable proportion from organic manures or in combination for sustaining of high level of production, is necessary to boost up rapeseed production.

b.4 Effect of integrated nutrient management on growth and yield attributes of pea

The effect of INM practices on plant height recorded at 30, 60 and 90 DAS and, leaves/plant recorded at 60 DAS are presented in Table 1 & 2. Results revealed that the plant height at 30 and 60 DAS did not differ significantly due to different INM practices. The plant heights at 90 DAS, due to 50% RDF + bio-fertilizers + 50% N through vermicompost which was followed by 75% RDF +25% N through vermicompost and 75% RDF +25% N through enriched compost were statistically at par but all being significantly superior to 100% RDF alone. In respect to number of leaves/plant, 50% RDF + bio-fertilizers + 50% N through vermicompost produced significantly the highest values (7.41 leaves/plant) over rest of the treatments. The plant population/m and dry matter/plant of pea due to INM practices (Table 2) did not vary significantly. However, 50% RDF + bio-fertilizers + 50% N through vermicompost produced significantly the highest values branches/plant (4.787/plant) over rest of the treatments and the lowest branches/plant was recorded under 100% RDF. Data on the yield attributing parameters of pea revealed that the pods/plant, length of pod and seeds/pod were increased significantly with 50% RDF + bio-fertilizers + 50% N through vermicompost (6.97 pods/plant, 6.61cm and 6.36 seed/pod, respectively), which were being at par with that of 75% RDF +25% N through vermicompost and proved superior to rest of the treatments. However, 1000-seed weight did not differ significantly due to different INM practices. The role of different bio-fertilizers like Rhizobium, BGA, Azotobactor, PSB, VAM etc. have been established in the economical nutrition of various crops (Pandey and Tripathi. 1993) [6] apart from building up of organic status of the soil due to which the availability of other nutrients also increases. Inoculation with Rhizobium had a significant impact on growth attributes over uninoculated (Fozia, *et al*., (2015) [5].

Table 1: Effect of inter-cropping system and integrated nutrient management on plant height (cm), 1000 seed weight (g) of rapeseed and pea crop.

Treatment	Plant Height (cm) of Rapsee			Plant Height (cm) of Pe			1000 Seed Weight (g)	
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	Rapeseed	Pea
Inter Cropping System								
C1: Sole Rapeseed	30.70	72.44	84.08	-	-	-	2.75	-
C2: Rapeseed : Pea (1:2)	31.04	75.23	85.26	8.51	31.78	35.07	2.73	188.46
C3 : Rapeseed : Pea (2:1)	31.23	74.80	83.21	8.55	31.54	35.53	2.53	188.18
C4: Rapeseed : Pea (2:2)	30.71	72.91	85.21	8.65	32.30	35.67	2.74	188.29
SEm+	0.66	1.04	0.57	0.26	0.53	0.32	0.06	2.20
CD : (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Integrated Nutrient Management								
M1 : RDF	29.67	73.08	84.38	7.87	31.95	34.33	2.60	1888.30
M2- 75% RDF+25% NEC	31.12	73.65	84.51	8.61	31.27	36.03	2.79	188.26
M3- 75% RDF+25% NVC	30.42	73.15	84.39	8.83	31.85	36.47	2.66	188.36
M4- 50% RDF+BF+50% NVC	31.65	74.50	85.40	8.96	32.43	36.99	2.69	188.32
SEm+	0.66	1.04	0.57	0.30	0.61	0.36	0.06	2.60
CD : (P = 0.05)	NS	NS	NS	NS	NS	1.08	NS	NS
Interection (C X M)	NS	NS	NS	NS	NS	NS	NS	

Note: NS=Non- significant, DAS= Days after sowing, RDF= Recommended Dose of Fertilizers, NEC= Nitrogen through enriched compost, NVC= Nitrogen throughvermicompost, BF=Biofertilizers

Table 2: Effect of inter-cropping system and integrated nutrient management on no. of leaves/plant, plant population /meter, no. of branches/plant, dry matter (g)/plant of rapeseed and pea.

Treatment	No. of Leaves/Plant		Plant Population /meter		No. of Branches/Plant		Dry Matter (g)/Plant	
	Rapeseed	Pea	Rapeseed	Pea	Rapeseed	Pea	Rapeseed	Pea
	30DAS	60DAS						
Inter Cropping System								
C1: Sole Rapeseed	4.84	9.44	-	20.64	-	5.71	-	6.95 -
C2: Rapeseed : Pea (1:2)	4.81	9.36	6.90	20.05	20.40	6.06	4.24	7.09 14.22
C3 : Rapeseed : Pea (2:1)	5.10	9.30	6.41	20.33	20.11	6.22	4.35	7.21 14.99
C4: Rapeseed : Pea (2:2)	5.55	9.53	7.31	20.77	21.08	6.12	6.62	7.06 14.35
SEm+	0.21	0.24	0.12	0.73	0.25	0.14	0.09	0.08 0.24
CD : (P = 0.05)	NS	NS	0.37	NS	NS	0.33	0.27	NS NS
Integrated Nutrient Management								
M1 : RDF	4.89	9.23	6.43	20.73	20.36	5.62	4.23	6.64 14.15
M2- 75% RDF+25% NEC	5.14	9.22	6.71	19.63	20.26	6.07	4.228	7.20 14.20
M3- 75% RDF+25% NVC	4.91	9.56	6.94	20.15	21.08	6.30	4.32	7.16 14.33
M4- 50% RDF+ BF+50% NVC	5.36	9.63	7.41	21.27	22.39	6.13	4.78	7.3 14.34
SEm+	0.21	0.24	0.14	0.74	0.29	0.11	0.10	0.08 0.28
CD : (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS NS

Table 3: Effect of inter cropping system and integrated nutrient management on No of Siliquae or Pods/ Plant, Length of Siliquae or Pods/ Plant, No of Seeds/Siliquae or Pods of rapeseed and pea.

Treatment	No of Siliquae or Pods/ Plant		Length of Siliquaeor Pods/Plant		No of Seeds/ Siliquae or Pods	
	Rapeseed	Pea	Rapeseed	Pea	Rapeseed	Pea
Inter Cropping System						
C1: Sole Rapeseed	32.50	-	6.88	-	16.03	-
C2: Rapeseed : Pea (1:2)	38.68	5.93	7.48	5.51	16.42	4.80
C2: Rapeseed : Pea (1:2)	39.76	6.17	7.44	5.61	16.22	4.83
C4: Rapeseed : Pea (2:2)	42.49	6.93	7.65	6.10	16.29	5.44
SEm+	0.22	0.70	0.67	0.12	0.21	0.13
CD : (P = 0.05)	0.67	2.02	0.51	0.37	NS	0.40
Integrated Nutrient Management						
M1 : RDF	33.89	5.50	6.63	5.63	15.67	4.54
M2- 75% RDF+25% NEC	39.37	6.25	7.71	5.91	16.47	5.07
M3- 75% RDF+25% NVC	41.45	6.66	7.39	6.14	16.28	5.13
M4- 50% RDF+ BF+50% NVC	38.73	6.97	7.71	6.61	15.54	5.36
SEm+	0.70	0.26	0.17	0.14	0.21	0.15
CD : (P = 0.05)	2.02	0.77	0.51	0.42	0.62	0.46
Interaction (C X M)	NS	NS	NS	NS	NS	NS

Conclusion

Based on the result obtained during the experimentation, it may be concluded that the performance of intercropping of rapeseed with pea under different integrated nutrient management (INM) practices conditions were found to be statistically alike in obtaining all the growth and yield attributes parameter of rapeseed and pea. Intercropping of rapeseed + pea 2:2 or 2.1 and INM practices of 75% RDF + 25% N through vermicompost or 50% RDF + biofertilizers + 50% N through vermicompost, significantly increased the growth and yield attributes.

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