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Quality attributes of pea and oat in an intercropping system in rice fallows as influenced by integrated nutrient management

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Abstract
A field experiment was conducted at two different areas of the Instructional-Cum-Research (ICR) farm of the Assam Agricultural University, Jorhat in 2014-15 and 2015-16 to study the "quality attributes of pea and oat in an intercropping system in rice fallows as influenced by integrated nutrient management". The treatments consist of four intercropping system viz. C_1: sole oats, C_2: sole pea, C_3: 3:2 row proportions and C_4: 3:3 row proportion of oat+pea intercropping and four integrated nutrient management Viz., F_1: RDF (inorganics), F_2: 50% N of RDF + 50% N through FYM, F_3: 50 % N of RDF + 50% N through vermicompost and F_4: 50%N through FYM + 50% N through vermicompost. Thus sixteen treatment combinations were laid out in split plot design with three replications with intercropping system in the main plots and INM in the sub-plots. The soils of the experimental site were acidic in reaction, sandy loam in texture, medium in OC, low in available N and P_2O_5 and medium in K_2O.Intercropping of pea with oat could not out yield the sole pea in terms of crude protein content, crude protein yield, nutrient content and uptakes in both the years however among the intercropping system the highest crude protein content, crude protein yield, nutrient content and uptakes was recorded in 3:3 row proportions of pea+oat in both the years of experimentations. The crude protein content, crude protein yield, nutrient content and uptakes due to integrated nutrient management was found to be highest at 50% N of RDF + 50% N through vermicompost during the years of experimentation. The crude protein content of oat was not affected by intercropping system, however the highest crude protein content of 10.36 and 10.46% was recorded in 50% N of RDF + 50% N through vermicompost followed by 50% N of RDF + 50% N through FYM during 2014-15 and 2015-16, respectively. The higher crude protein yield was recorded in sole oats in both the years of experiment. Among the intercropping 3:2 gave the highest value of 3.84 and 4.43q/ha crude protein yield during 2014-15 and 2015-16, respectively. The N, P, K, Zn and Fe content of oats was found to be significantly higher in 3:3 row proportions of pea+oat intercropping over the sole cropping of oat however the nutrient uptakes were found to be highest in sole oat in both the years. Among the intercropping systems nutrient uptakes observed in C_3 (3:2 row proportions) was higher than C_4 (3:3 row proportions of pea+oat intercropping) in both the years of experimentation. Application of nutrients at 50% N of RDF + 50% N through vermicompost (F_3) resulted significantly higher nutrient content and uptakes of oats as compared to F_1 (100% RDF), F_2 (50% N of RDF + 50% N through FYM) and F_4 (100% organic i.e. 50% N of vermicompost + 50% N through vermicompost) in both the years. Therefore, in pea and oat intercropping system under rice fallows, it can be recommended to apply 50% RDF through vermicompost + 50% RDF through inorganic fertilizers, which will increase the nutrient content and uptake of the crops with 3:3 row proportions of pea+oat intercropping systems.

Keywords: Quality attributes of pea and oat, rice fallow, integrated nutrient management, FYM, vermicompost

Introduction
Agriculture and animal husbandry in India are interwoven with the intricate fabric of the society in cultural, religious and economical ways as mixed farming and livestock rearing forms an integral part of rural living. Although the contribution of agricultural sector in the Indian economy is steadily declining, the agriculture and livestock sector still provides employment to 52% of the work force with an area under cultivated fodder 8.6 million hectares (Kumar *et al*., 2012). Crop production system is closely linked with animal husbandry as a complementary enterprise. Crops are of prime importance for economic feeding of animal on one hand, and on the other hand, the livestock through the supply of organic manures and draft power helps in balancing crop growth. The importance is more emphasized in India, as it owns the largest livestock population in the world and accounts nearly 16 per cent of the world's cattle population. The contribution of livestock sector to agriculture GDP accounts for 25% of agricultural output and now India has become the largest producer of milk in the

world. Most often, livestock is the only source of cash income for subsistence farms and also serves as insurance in the event of crop failure. An integral approach of the pea- oat production aims at obtaining food and fodder crop simultaneously from the same piece of land at the same time. In view of this, it would be desirable, more profitable and economically viable to introduce the intercropping system to explore both temporal and spatial advantage as well as for long term productivity and sustainability of the system. However, meager information is available on the effect of organic and inorganic source of nutrition on pea-oat. Therefore, an attempt was made to evaluate different organic and inorganic sources of nutrition for realizing the quality in pea-oat intercropping.

Materials and Methods

The present investigation was carried out in the sandy loam soil of the Instructional-Cum Research (ICR) Farm of Assam Agricultural University, Jorhat, located at 26^0 45' N latitude and 94^0 12' E longitudes at an elevation of about 87 m above mean sea level. The soil was medium in organic carbon (0.52 and 0.53%) content, low in available nitrogen (207.50 and 213.47 kg/ha) and medium in available phosphorus (22.52 and 23.12 kg/ha), potassium (145.31 and 148.71 kg/ha), DTPA-Zn (1.25 and 1.26 mg/kg) and DTPA-Fe (116.33 and 120.51 mg/kg) with acidic (pH in 5.2 and 5.4) in reaction having 1.29 and 1.27 Mg/m^3 bulk density, Mean weight diameter 0.54 and 0.57 mm and biomass carbon 150.42 and 158.37 $\mu g\ g^{-1}$. The experiment was laid out in split plot design with three replications for two years. There were four main plot treatments comprising of sole crop oat, sole crop pea, different row proportion of oat and pea i.e. 3:2 and 3:3 along with four combinations of nutrient management viz. RDF (inorganics), 50% N of RDF + 50% N through FYM, 50 % N of RDF + 50% N through vermicompost and 50% N through FYM + 50% N through vermicompost were superimposed on each of the main plots as subplot treatments. The seeds of oat were treated with PSB and pea seeds were treated with PSB and Rhizobium culture @ 100g/kg seeds for all the treatment combinations before sowing of seeds.

Result and Discussion

Quality attributes of pea and oat as influenced by intercropping system and integrated nutrient management

Nutrient content and uptake by pea as influenced by intercropping system

The result of the two years study shows that significantly highest crude protein content was recorded in sole pea. Among the intercropping systems the highest was found to be recorded in 3:3 pea+oat row proportion over 3:2 during 2014-15 and 2015-16, respectively. Higher crude protein yield in sole pea resulted CPY of 7.86 and 9.48 q/ha and among the intercropping systems the highest was recorded in 3:3 ratio of pea+oat with the value of 3.54 and 4.22 during 2014-15 and 2015-16, respectively. The highest forage quality parameters were achieved when pea was grown as a monoculture or when at a high proportion in mixture. (Kocer and Albayrak, 2012). N-content was increased in sole pea than the intercropping systems during both the years of experimentation. Among the intercropping system 3:3 row proportions of pea+oat gave the highest N-content. The N-uptake due to intercropping was found to be significant in both the years. The highest N-uptake was recorded in sole pea and among the intercropping systems the wider row proportions i.e 3:3 row ratio gave higher N-uptake than 3:2 row proportions of pea+oat during 2014-15 and 2015-16.Significantly higher P-content and K-content was recorded in the sole pea than other intercropping systems during 2014-15 and 2015-16, respectively. Among the intercropping systems the highest P-content and K-content was observed in 3:3 row proportions of pea+oat in both the years of experimentation. The highest P-uptake and K-uptake was recorded in sole pea than other intercropping systems. Among the intercropping systems the highest P and Kuptake by pea was observed in 3:3 row proportions of pea+oat in both the years. Micronutrient like zinc and iron content was observed to be highest in sole pea cropping during 2014-15 and 2015-16, respectively. The highest among the intercropping systems was obtained in 50% pea population i.e. in 3:3 ratios of pea+oat during the years of experimentation respectively, significantly higher zinc and iron uptake was recorded in sole pea than other intercropping systems which was followed by 3:3 row proportions of pea+oat row proportion.

Nutrient content and uptake by pea as influenced by integrated nutrient management

Protein content of 26.62 and 27.38 per cent were recorded in 50% N through vermicompost + 50% N through inorganic fertilizer followed by 50% N through FYM + 50% N through inorganic fertilizers during 2014-15 and 2015-16, respectively.Pea crop was found to be significantly affected by integrated nutrient management on nutrient content and its uptake in 2014-15 and 2015-16, experimentation. The highest nutrient content (N, P, K, Zn and Fe) was recorded in 50% N through vermicompost + 50% N through inorganic fertilizer followed by 50% N through FYM + 50% N through inorganic fertilizers during the two years of experimentation. As far as the organic manures are concerned, the vermicompost proved to be a better alternative to the FYM owing to its higher nutrient content and other associated properties (Sharma and Chauhan, 2011). The uptakes of nutrient were also observed to be the highest in 50% N through vermicompost + 50% N through inorganic fertilizer.Integrated nutrient management (INM) through application of FYM or vermicompost in combination with 75% NPK enhanced N, P and K uptake by garden pea as compared to organics or 100% NPK alone (Sepehya *et al*., 2015).

Nutrient content and uptake by oatas influenced by intercropping system

Crude protein content was found to be non-significant as influenced by intercropping systems. However, the highest crude protein content was observed in 3:3 row proportions recording 8.87 % and 8.98 % in 2014-15 and 2015-16, respectively similarly, Lauk and Lauk, 2008also reported that pea+oat intercropping gave the highest yield of grain and protein yields. The highest crude protein yield was observed in C_1 (sole oats) and among the intercropping the highest crude protein yield was recorded in C_4 (3:3 ratio of pea+oat) and the least was observed in C_3 (3:2 ratio of oat+pea) in both the years of experimentation. The fodder quality was considerably higher in mixtures as compared to pure oats. A similar finding was reported by Tiwani *et al*. 2008.The highest nitrogen content of 1.42% was recorded in C_4 (3:3 ratio of oat+pea intercropping) followed by C_3 (3:2 ratio of pea+oat) (1.38%) over the sole oat 1.31% in 2014-15. Similarly in 2015-16, the highest nitrogen content of 1.44% was recorded in C_4 (3:3 row proportions of pea+oat) followed by C_3 (3:2 row proportions of pea+oat) which was

significantly higher than C_1 (sole oat). The highest N-uptake was observed in sole oat and among the intercropping systems the highest N-uptake was found in 3:2 ratio of pea+oat in both the years of experimentation.Carr *et al*., 2004 also reported that intercropping of oat/barley with pea increased forage yield and N content.P-content tended to increase in the intercropping as compared to sole oats. The highest P-content was recorded in 3:3 row proportions of pea+oat over 3:2 row proportion in both the years of experimentation.The sole oats culture recorded the highest P-uptake as compared to other intercropping systems. In 3:3 ratio pea+oat uptake was found at par with 3:2 row proportion in both the years.K-content in oats was found to be significant in both the years of experiment during 2014-15 and 2015-16. The K-content increased significantly in 3:3 ratio of pea+oat intercropping followed by 3:2 ratio of pea+oat intercropping in both the years. Effect of intercropping on K-uptake in oats was observed to be higher in sole oats. Among the intercropping systems the highest K-uptake was observed in 3:2 row proportions of pea+oat in both the years of experiment. As far as the micronutrient is concerned, the content of zinc and iron in oats was highest in 3:3 pea+oat intercropping system followed by 3:2 row proportion in both the years of experimentation. The highest Zinc-uptake by oats due to intercropping was recorded (0.70 and 0.85mg/kg) in 3:2 row proportions than 3:3 row proportions of pea+oat in both the years of experimentation. The highest Fe uptake was recorded in sole oats in both the years of experimentations. Among the intercropping systems the highest Fe uptake was recorded in C_3 (3:2 ratio of oat+pea intercropping) over 3:3 row proportion during 2014-15 and 2015-16, respectively.

Nutrient content and uptake by oatas influenced by integrated nutrient management

Protein content is one of the most important parameters affecting the nutritional value of fodder crops. It was evident from the data that crude protein was affected significantly by integrated nutrient management. The highest crude protein content of 10.36% and 10.46% respectively was observed in F_3 (50% N through vermicompost + 50% N through inorganic fertilizer) followed by F_2 (50% N through FYM + 50% N through inorganic fertilizer) over F_4 (50% N through vermicompost + 50% N through FYM) which was at par with F_1 (RDF) in both the years.Similarly thehighest crude protein yield was also observed in F_3 (50% N through vermicompost + 50% N through inorganic fertilizer) during the years of experimentation. Application of inorganic fertilizer with organic improves crude protein and crude protein yield of *kharif* rice bean and *rabi* oats as reported by Hembram and Kundu, 2016.Content of N, P, K, Zn and Fe in oats was found to be significant due to integrated nutrient management in both the years of experimentations. The content of the nutrients was higher with the application of 50% N through vermicompost + 50% N through inorganic fertilizer followed by 50% N through FYM + 50% N through inorganic fertilizer during 2014-15 and 2015-16. A similar trend of observation was also recorded in nutrient uptakes in both the years of experimentation.

Based on the two year experimentation, it can be concluded that, in the rice-fallow systems, introduction of food-forage intercropping systems having component crop of pea and oat with planting geometry of 3:3 row proportion having considerable positive effect on the increase of nutrient content and uptake of the crops and also addition of vermicompost can saved 50% of inorganic fertilizers.

Table 1: Crude Protein content, crude protein yield and N-content of pea as influenced by cropping systems and INM

Treatments	CP (%)		CPY (q/ha)		N-content (%)		N-uptake (kg/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Cropping system (C)								
C_1	-	-	-	-	-	-	-	-
C_2	23.44	24.10	7.86	9.48	3.75	3.86	125.76	151.71
C_3	21.16	21.90	2.57	3.09	3.38	3.50	41.11	49.39
C_4	22.13	22.92	3.54	4.22	3.54	3.67	56.41	67.54
SEm±	0.42	0.42	-	-	0.06	0.07	-	-
CD (P=0.05)	1.96	1.94	-	-	0.31	0.34	-	-
Integrated nutrient management (F)								
F_1	20.81	21.54	3.87	4.57	3.33	3.45	61.89	73.12
F_2	23.37	24.13	5.26	6.35	3.74	3.86	84.16	101.63
F_3	26.62	27.38	6.35	7.75	4.26	4.38	101.54	124.07
F_4	18.16	18.85	3.15	3.71	2.91	3.01	50.46	59.37
SEm±	0.61	0.76	-	-	0.09	0.04	-	-
CD (P=0.05)	3.04	3.77	-	-	0.48	0.23	-	-
Interaction (CxF)								
SEm±	1.06	1.32	-	-	0.17	0.08	-	-
CD (P=0.05)	NS	NS	-	-	NS	NS	-	-
CV (%)	5.73	5.50	-	-	5.73	6.02	-	-

Table 2: N, P and K-content and uptake by pea as influenced by cropping systems and INM

Treatments	P-content (%)		P-uptake (kg/ha)		K-content (%)		K-uptake	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Cropping system (C)								
C_1	-	-	-	-	-	-	-	-
C_2	0.31	0.33	10.31	13.11	1.53	1.55	51.14	60.85
C_3	0.26	0.28	3.13	3.98	1.36	1.38	16.40	19.35
C_4	0.28	0.31	4.59	5.79	1.45	1.46	23.13	26.85
SEm±	0.005	0.01	-	-	0.03	0.03	-	-
CD (P=0.05)	0.025	0.04	-	-	0.14	0.16	-	-
Integrated nutrient management (F)								
F_1	0.25	0.27	4.70	5.68	1.35	1.37	25.05	29.02
F_2	0.31	0.35	7.17	9.33	1.53	1.55	34.59	41.02
F_3	0.35	0.38	8.25	10.67	1.68	1.70	39.94	48.16
F_4	0.22	0.24	3.92	4.82	1.22	1.24	21.31	24.54
SEm±	0.11	0.005	-	-	0.01	0.04	-	-
CD (P=0.05)	0.55	0.027	-	-	0.09	0.21	-	-
Interaction (CxF)								
SEm±	0.01	0.009	-	-	0.03	0.07	-	-
CD (P=0.05)	NS	NS	-	-	NS	NS	-	-
CV (%)	5.87	8.67	-	-	6.35	7.15	-	-

Table 3: Zinc and iron content and uptake by pea as influenced by cropping systems and INM

Treatments	Zn-content mg/kg		Zn-uptake (mg/kg)		Fe-content mg/ha		Fe-uptake (mg/kg)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Cropping system (C)								
C_1	-	-	-	-	-	-	-	-
C_2	0.034	0.036	1.14	1.40	45.29	46.48	1501.57	1805.01
C_3	0.032	0.032	0.38	0.45	43.79	44.93	524.26	623.17
C_4	0.033	0.034	0.52	0.62	44.54	45.72	702.97	828.30
SEm±	0.0004	0.0007	-	-	0.90	0.81	-	-
CD (P=0.05)	0.002	0.003	-	-	NS	NS	-	-
Integrated nutrient management (F)								
F_1	0.031	0.032	0.58	0.69	43.33	44.60	795.01	933.66
F_2	0.035	0.036	0.79	0.95	45.25	46.50	1009.62	1212.93
F_3	0.036	0.038	0.86	1.08	47.08	48.09	1110.23	1350.94
F_4	0.029	0.029	0.49	0.58	42.50	43.66	723.54	844.44
SEm±	0.0006	0.0008	-	-	0.72	0.83	-	-
CD (P=0.05)	0.003	0.004	-	-	3.56	4.14	-	-
Interaction (CxF)								
SEm±	0.001	0.001	-	-	1.25	1.44	-	-
CD (P=0.05)	NS	NS	-	-	NS	NS	-	-
CV (%)	4.08	7.04	-	-	6.09	5.37	-	-

Table 4: Crude protein content, crude protein yield and N-content of oat as influenced by cropping systems and INM

Treatments	CP (%)		CPY (q/ha)		N-content (%)		N-uptake (kg/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Cropping system (C)								
C_1	8.19	8.36	6.93	7.83	1.31	1.34	110.90	125.31
C_2	-	-	-	-	-	-	-	-
C_3	8.66	8.76	3.84	4.43	1.38	1.40	61.41	70.82
C_4	8.87	8.98	3.29	3.85	1.42	1.61	52.64	61.69
SEm±	0.24	0.22	-	-	0.03	0.02	-	-
CD (P=0.05)	NS	NS	-	-	0.14	0.10	-	-
Integrated nutrient management (F)								
F_1	7.82	7.94	3.89	4.58	1.25	1.27	62.19	73.32
F_2	8.99	9.14	5.06	5.76	1.44	1.46	80.98	92.11
F_3	10.36	10.46	6.48	7.32	1.66	1.67	103.64	117.20
F_4	7.12	7.26	3.32	3.82	1.14	1.16	53.11	61.13
SEm±	0.30	0.17	-	-	0.03	0.01	-	-
CD (P=0.05)	1.50	0.86	-	-	0.19	0.08	-	-
Interaction (CxF)								
SEm±	0.52	0.30	-	-	0.06	0.02	-	-
CD (P=0.05)	NS	NS	-	-	NS	NS	-	-
CV (%)	8.44	7.59	-	-	6.66	5.09	-	-

Table 5: P and K- content and uptake by oat as influenced by cropping systems and INM

Treatments	P-content (%)		P-uptake (kg/ha)		K-content (%)		K-uptake (kg/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Cropping system (C)								
C_1	0.147	0.151	12.42	14.21	0.93	0.95	78.16	88.60
C_2	-	-	-	-	-	-	-	-
C_3	0.152	0.157	6.58	7.92	0.96	0.98	42.47	49.65
C_4	0.157	0.161	5.99	6.93	1.00	1.01	36.84	43.46
SEm±	0.004	0.006	-	-	0.03	0.02	-	-
CD (P=0.05)	NS	NS	-	-	NS	NS	-	-
Integrated nutrient management (F)								
F_1	0.142	0.148	7.04	8.51	0.86	0.88	42.57	50.35
F_2	0.161	0.165	9.06	10.39	1.07	1.10	60.64	69.30
F_3	0.184	0.188	11.56	13.23	1.12	1.14	69.93	80.39
F_4	0.121	0.125	5.68	6.63	0.79	0.80	36.81	42.24
SEm±	0.009	0.010	-	-	0.01	0.01	-	-
CD (P=0.05)	0.047	0.049	-	-	0.09	0.08	-	-
Interaction (CxF)								
SEm±	0.01	0.017	-	-	0.03	0.03	-	-
CD (P=0.05)	NS	NS	-	-	NS	NS	-	-
CV (%)	8.55	11.54	-	-	10.21	8.37	-	-

Table 6: Zinc content and uptake by oat as influenced by cropping systems and INM

Treatments	Zn-content (mg/kg)		Zn-uptake (mg/kg)		Fe-content mg/ha		Fe-uptake (mg/kg)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Cropping system (C)								
C_1	0.015	0.016	1.28	1.53	35.63	37.54	2990.14	3484.58
C_2	-	-	-	-	-	-	-	-
C_3	0.016	0.017	0.70	0.85	36.95	39.05	1621.85	1955.55
C_4	0.017	0.018	0.63	0.77	38.07	40.38	1396.59	1720.43
SEm±	0.0003	0.0003	-	-	0.43	0.57	-	-
CD (P=0.05)	0.001	0.001	-	-	2.01	2.66	-	-
Integrated nutrient management (F)								
F_1	0.014	0.15	0.70	0.87	35.52	37.47	1770.55	2158.00
F_2	0.017	0.018	0.97	1.14	38.32	40.22	2164.20	2531.57
F_3	0.019	0.021	1.20	1.47	40.04	42.24	2506.53	2961.48
F_4	0.013	0.014	0.61	0.72	33.65	36.02	1570.18	1896.37
SEm±	0.0004	0.0003	-	-	0.66	0.50	-	-
CD (P=0.05)	0.002	0.001	-	-	3.30	2.47	-	-
Interaction (CxF)								
SEm±	0.0007	0.0006	-	-	1.15	0.86	-	-
CD (P=0.05)	NS	NS	-	-	NS	NS	-	-
CV (%)	6.34	6.79	-	-	3.56	4.44	-	-

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