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PRODUCTIVITY OF FOOD-FORAGE INTERCROPPING SYSTEM AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

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SUMMARY

A field experiment was conducted at two different areas of the Instructional-Cum-Research (ICR) farm of the Assam Agricultural University, Jorhat (Assam) in 2014-15 and 2015-16 to study the "Productivity of food-forage intercropping system as influenced by integrated nutrient management". The treatments consist of four intercropping system viz. C1: sole oats, C2: sole pea, C3: 3:2 row proportions and C4: 3:3 row proportion of oat+pea intercropping and four integrated nutrient management Viz., F1: RDF (inorganics), F2: 50% N of RDF + 50% N through FYM, F3: 50 % N of RDF + 50% N through vermicompost and F4: 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. Highest green forage and dry matter yield was recorded in sole oats, among the intercropping system the highest green forage yield of 199.38 and 217.98 q/ha and dry matter yield of 43.52 and 49.72 q/ha was recorded in 3:2 row proportions during 2014-15 and 2015-16 respectively. Application of 50% N of RDF + 50% N through vermicompost to oats gave the highest green forage and dry matter yield during 2014-15 and 2015-16. Superior pod yield was recorded in sole pea culture showing the value of 44.74 and 47.24 q/ha in 2014-15 and 2015-16 respectively. The pea equivalent yield was observed to be highest in sole pea but among the intercropping system statistically superior pea equivalent yield was recorded in 3:3 row proportions over 3:2 row proportions and sole oats in both the experimental years. Integrated nutrient management on pod yield, green forage yield, dry matter yield and pea equivalent yield was significantly higher in 50 % N of RDF + 50% N through vermicompost than the other treatment combination in both the years. Therefore, in oat-pea intercropping system, it can be recommended to apply 50% RDF through vermicompost + 50% RDF through inorganic fertilizers, which will reduce the load of chemical fertilizers up to 50% with 3:3 row proportions of oat+pea intercropping systems.

Key words : Food-forage, integrated nutrient management, FYM, vermicompost

Food-forage-based systems provide a support to small and marginal farmers by adjusting a substantial part of their land exclusively for forage production in grain crop based rotations. Efficient cropping system with respect to biological potential along with increased efficiencies of land and water are to be evaluated for specific regions (Yadav *et al.*, 1998). Forages offer a great scope in contingent planning as short duration catch/intercrop or alley crop under different resource use situation to support livelihood through enhanced livestock productivity. With the current growth trend in livestock products strategies should be oriented towards promotion of forage based cropping system or inclusion of forages as sole, mixed or intercrop in existing cropping situation to narrow down the gap in demand and supply matching with agro-economic environmental condition (Agrawal *et al.*, 2008). Integrated nutrient management helps maintain soil fertility and improve plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources on a long-term basis. The continuous use of high levels of chemical fertilizers is adversely affecting the sustainability of agricultural production and causing environmental pollution (Virmani 1994). Organic matter plays a vital role for crop production. Due to huge demand of chemical fertilizer, consequently changing scenario of soil fertility management, the organic fertilizers can play a vital role in restoring fertility as well as organic matter

status of the cultivating soils. However, meager information is available on the effect of organic and inorganic source of nutrition on food-forage. Therefore, an attempt was made to evaluate different organic and inorganic sources of nutrition for realizing higher yield and quality in oat-pea 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 ?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.

RESULTS AND DICUSSIONS

Growth and productivity

Intercropping systems

The result of the two years study shows that plant height was significantly highest in sole oats. The number of tillers and leaf-stem ratio was found to be enhanced by intercropping systems at 3:3 ratio of oat-pea while sole cropping of oat and 3:2 ratio of oat-pea intercropping shows lower number of tillers which might be due to higher level of inter and intra species competition for growth and development. The Crop Growth Rate (CGR) of oat increased continuously with the advancement of the crop phenological stages upto 50% flowering stage i.e. at the time of harvest. The sole oat exhibited the highest CGR over all other intercropping systems. This might be attributed to the process of simultaneously operative vegetative and reproductive phases. The CGR was reduced by intercropping systems. A consistent trend of RGR could not be noticed in all the cropping systems. The observed improvement in various characters might be owing to beneficial effect of legumes on cereal as legume fixes nitrogen in the soil through the process

TABLE 1
Plant height, No. of tillers/m, dry matter content, L:S ratio and LAI of oats as influence by intercropping and INM

Treatments	Plant height (cm) at 80 DAS		No. of tillers/ m		Dry matter content (%)		L : S ratio		LAI at 80 DAS	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Intercropping (C)										
C_1	105.95	112.22	128.33	134.50	23.67	24.11	0.34	0.36	4.15	4.42
C_2	-	-	-	-	-	-	-	-	-	-
C_3	99.46	105.06	136.17	144.33	21.05	22.13	0.35	0.38	4.25	4.78
C_4	102.38	109.43	143.67	153.67	22.00	23.37	0.37	0.40	4.27	5.07
S. Em±	1.21	1.24	1.47	2.06	0.77	0.72	0.005	0.009	0.04	0.21
C. D. (P=0.05)	5.56	5.73	6.82	9.53	NS	NS	0.02	0.04	NS	NS
Integrated nutrient management (F)										
F_1	96.51	104.95	126.56	133.22	21.10	22.67	0.30	0.33	3.97	4.33
F_2	108.56	113.90	142.11	151.78	22.87	23.56	0.39	0.41	4.22	4.68
F_3	122.33	129.58	160.33	170.22	24.00	25.30	0.45	0.48	5.15	6.02
F_4	79.99	87.19	115.22	121.44	20.37	21.29	0.27	0.30	3.54	3.99
S. Em±	3.94	2.76	1.70	2.13	0.50	0.24	0.009	0.01	0.08	0.10
C. D. (P=0.05)	19.47	13.64	8.42	10.52	2.48	1.23	0.04	0.06	0.40	0.53

of biological nitrogen fixation, which is utilized by the oat and its role in tillering is well established. These findings was corroborating with the findings of Kumar and Jeengar (2015). The highest green forage yield and dry matter yield was recorded in sole oats, among the intercropping systems 3:2 row proportions produced higher green forage and dry matter yield than 3:3 system in both the years. This might be due to higher plant population i.e. 60% oat population than 50 % population in 3:2 cropping systems. Plant height of pea, number of plants per meter, number of branches per plant, leaf-stem ratio and dry matter content was recorded superior in sole pea over other intercropping system which might due to less nutrient competition and no shading effect by oats. Among the intercropping system the highest was observed in 3:3 row proportions. The phonological growth parameters like LAI, CGR and RGR of pea was also significantly higher in sole pea. The yield contributing characters viz. seeds per pod, length of pods and shelling percent were not affected by intercropping systems. The highest number of pods (8.10 and 8.99) was recorded in sole pea followed by C_4 (3:3 ratio of oat-pea). The lower number of pods per plant in 3:2 and 3:3 cropping systems might be due to adverse effect of higher plant population since in addition to 100 percent of sole pea population, these two systems has 60 and 50 percent of sole oats population respectively. Significantly higher pod yield of 44.74 and 47.24 q/ha was recorded in sole pea as compared to other intercropping systems during 2014-15 and 2015-16 respectively. Increased in pod yield in wider row proportions might be due to reduced shading and better utilization of light and other natural resources. Intercropping reduced the pod yield of pea by 64.08% and 64.82 % during the successive two years experimentation respectively. That means that the leguminous were shadowed by the oat plants and the plants from the mixture competed for light, water and nutrients. The findings are similar with Dusa. (2013). Green forage yield and dry matter yield due to intercropping have been differed significantly during the years of experimentations. The highest GFY and DMY of pea was recorded in sole pea The green forage and dry matter yield among the intercropping was highest in 3:3 row proportions than 3:2 row proportions in both the years. These might be attributed to crowding effect due to higher population density. Among the intercropping 3:3 row proportions performs the best by giving higher green forage yield, dry matter yield and pod yield. The findings are in close conformity with the findings of Ates (2012).

Integrated nutrient management

Growth of oats in terms of plant height was recorded to be highest in 50% N through Vermicompost + 50% N of RDF through inorganic fertilizers and the lowest plant height was recorded

TABLE 2
CGR, RGR, GFY and DMY of oat as influence by intercropping and INM

Treatments	CGR (q/ha/day)		RGR(g/g/day)		GFY (q/ha)		DMY (q/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Intercropping (C)	60-80 DAS	60-80 DAS	60-80 DAS	60-80 DAS				
C_1 oat sole	4.64	5.02	0.013	0.013	357.11	382.35	83.39	92.33
C_2 pea sole	-	-	-	-	-	-	-	-
C_3 oat+pea (3:2)	4.27	4.69	0.013	0.013	199.38	217.98	43.52	49.72
C_4 oat+pea (3:3)	4.47	4.85	0.013	0.013	172.49	186.52	36.40	42.34
S. Em±	0.05	0.05	0.0001	0.0003	3.05	5.65	0.70	0.64
C. D. (P=0.05)	0.26	0.23	NS	NS	14.08	26.07	3.26	2.96
Integrated nutrient management (F)								
F_1 RDF (inorganic)	4.24	4.62	0.014	0.013	232.25	252.03	50.42	58.28
F_2 50% N of RDF+50% N through FYM	4.72	5.03	0.012	0.012	247.17	267.26	57.02	63.45
F_3 50% N of RDF+50% N through vermicompost	4.85	5.40	0.011	0.011	264.54	282.00	63.15	70.80
F_4 100% organic (50% N through FYM+50% N through vermicompost)	4.02	4.37	0.015	0.015	228.02	247.84	47.16	53.32
S. Em±	0.06	0.07	0.0005	0.0002	4.11	3.02	0.56	1.05
C. D. (P=0.05)	0.75	0.38	0.002	0.001	20.32	14.95	2.76	5.19

TABLE 3
Plant height, No. of tillers/m no. of branches/plants, L : S ratio and LAI of pea as influence by intercropping and INM

Treatments	Plant height (cm) at 80 DAS		No. of plants/ m		No. of branches/ plant		L : S ratio		LAI at 80 DAS	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Intercropping (C)										
C_1	-	-	-	-	-	-	-	-	-	-
C_2	41.61	43.72	19.66	20.68	2.28	2.41	0.73	0.76	3.23	3.35
C_3	38.89	40.79	17.57	18.59	2.19	2.32	0.69	0.72	2.77	2.90
C_4	40.18	42.44	18.62	19.65	2.24	2.36	0.71	0.74	2.96	3.08
S. Em±	0.48	0.48	0.37	0.36	0.06	0.06	0.007	0.01	0.06	0.04
C. D. (P=0.05)	2.22	3.44	1.71	1.70	NS	NS	0.03	0.04	0.30	0.19
Integrated nutrient management (F)										
F_1	38.96	40.31	18.29	19.32	2.16	2.29	0.63	0.66	2.81	2.89
F_2	41.69	43.34	18.93	19.94	2.32	2.46	0.75	0.79	3.12	3.30
F_3	43.77	48.80	19.45	20.45	2.39	2.51	0.88	0.92	3.62	3.73
F_4	36.49	36.81	17.82	18.85	2.10	2.22	0.58	0.60	2.40	2.50
S. Em±	0.91	0.71	0.18	0.20	0.08	0.08	0.02	0.02	0.05	0.04
C. D. (P=0.05)	4.49	3.53	0.92	1.02	NS	NS	0.11	0.20	0.28	0.21

with 100% organic fertilizer supplements in both the years of experimentations. A similar finding was also reported by Kannan, *et al.,* 2013. The number of tillers per meter row length and leaf-stem ratio and dry matter content was significantly higher in 50% N through Vermicompost + 50 % N of RDF through inorganic fertilizers. This might be due to adequate and continuous supply of nutrients at different stages due to sufficient amount of nutrients by easy mineralization in vermicompost in comparison to FYM at a constant level that resulted in higher plant growth. This result is in close conformity with the findings of Godara *et al*. (2012). The highest LAI, CGR and RGR was observed in the treatment receiving 50% N through Vermicompost + 50 % N of RDF through inorganic fertilizers (F_3) in both the years. The increased in green fodder yield of 13.80 and 12.11 percent was recorded in F_3 (50% N through vermicompost + 50 % N through inorganic fertilizer) over F_4 (50% N through vermicompost + 50 % N through FYM) in 2014-15 and 2015-16 respectively. The highest dry matter yield of 63.15 and 70.80 q/ha was recorded in F_3 (50% N through vermicompost + 50 % N through inorganic fertilizer) in 2014-15 and 2015-16 respectively, which was at par with F_2 (50% N through FYM + 50 % N through inorganic fertilizer). The treatments receiving

TABLE 4
Days to 50% flowering, Dry matter content, CGR and RGR of pea as influence by intercropping and INM

Treatments	Days to 50% flowering		Dry matter content (%)		CGR (q/ha/day)		RGR (g/g/day)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Intercropping (C)								
C_1	-	-	-	-	-	-	-	-
C_2	44.96	47.04	14.28	15.24	0.175	0.180	0.013	0.013
C_3	44.60	46.40	13.85	14.79	0.143	0.150	0.013	0.012
C_4	44.68	46.64	14.10	15.03	0.161	0.168	0.013	0.013
S. Em±	0.94	0.88	0.31	0.44	0.003	0.002	0.0004	0.0003
C. D. (P=0.05)	NS	NS	NS	NS	0.016	0.12	NS	NS
Integrated nutrient management (F)								
F_1	44.39	46.00	13.51	14.29	0.135	0.142	0.013	0.012
F_2	44.90	47.25	14.53	15.59	0.172	0.178	0.013	0.013
F_3	46.15	48.34	15.05	16.25	0.251	0.259	0.015	0.014
F_4	43.55	45.19	13.21	13.95	0.080	0.86	0.012	0.011
S. Em±	0.63	0.82	0.21	0.26	0.004	0.001	0.0003	0.0002
C. D. (P=0.05)	NS	NS	1.05	1.32	0.019	0.008	0.001	0.0014

50% N through vermicompost + 50 % N through inorganic fertilizer recorded the highest green forage and dry matter yield of oats. This result is in close conformity with the findings of Sharma *et al*. 2004 and Devi *et al*., 2014. Significantly higher green forage and dry matter yield of oats might be due to higher values of growth parameters with this treatment. The use of organic manures helps in economizing the use of chemical fertilizers. The result confirms the findings of Godara *et al*. 2012. Jayanthi *et al*., 2002 also advocated the use of combined application of nutrients through organic and inorganic fertilizer in oat for higher productivity and sustainability.

The highest plant height was recorded in 50% N through Vermicompost + 50 % N of RDF through inorganic. Number of branches and days to 50 % flowering of pea was not affected by nutrient management in both the years of experimentations. Number of plant per meter row length, LAI, leaf:stem ratio and dry matter content of pea was found to be highest in 50% N through vermicompost + 50 % N of RDF through inorganic fertilizers and followed by 50% N through vermicompost + 50 % N of RDF through FYM as compared to 100 % inorganics and organic fertilizers during the years of experimentations. Similar results were also reported by Qureshi et al., 2015. Significantly higher CGR and RGR was recorded in F_3 (50% N through vermicompost + 50 % N through inorganic fertilizer) during 2014-15 and 2015-16 followed by F_2 (50% N through vermicompost + 50 % N through inorganics). Effect of integrated nutrient management on pea yield parameters like pods per plant, number of seeds per pod, Length of pods and shelling percent were found to be significantly highest in the treatment combinations of 50% N through vermicompost + 50 % N through inorganic fertilizer and the lowest was being observed in 50% N through vermicompost + 50 % N through FYM in both the years of experimentations. A similar finding was reported by Ilhe *et al*., 2007. The pod yield of pea was found to be significantly higher (33.12 and 34.32 q/ha) in F_3 (50% N through vermicompost + 50 % N through inorganic fertilizer) which was at par with F_2 (50% N through FYM + 50 % N through inorganic fertilizer) during 2014-15 and 2015-16 respectively. The increased in yield might be due to the use of vermicompost which is rich in major nutrients and in addition to that it also contains micronutrients which are easily available for the development of plants. This finding is in corroboration with the findings of Dubey et al., 2012. Significantly the highest green fodder and dry matter yield was observed in F_3 (50% N through vermicompost + 50 % N through inorganic fertilizer) which was at par with F_2 (50% N through FYM + 50 % N through inorganic fertilizer). Application of 50% N through vermicompost + 50 % N through inorganic fertilizer to field pea resulted in higher yield attributing characters, dry matter yield, green forage yield and pod yield. This is in conformity with the results of Kumari *et al*. 2012.

CONCLUSION

Based on the two year experimentation, it can be concluded that, in the rice-fallow systems,

TABLE 5

No. of pods/plant, No. of seeds/plant, length of pods, pod yield and shelling% pea as influence by intercropping and INM

Treatments	No. of pods/plant		No. of seeds/pods		Length of pods (cm)		Pod yield (q/ha)		Shelling %	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Intercropping (C)										
C_1	-	-	-	-	-	-	-	-	-	-
C_2	8.10	8.99	5.58	6.15	7.90	8.06	44.74	47.24	49.09	50.02
C_3	7.27	8.19	5.22	5.75	7.69	7.81	16.07	16.62	47.31	48.20
C_4	7.70	8.51	5.39	5.95	7.79	7.93	21.42	22.09	48.19	49.06
S. Em±	0.13	0.11	0.16	0.13	0.12	0.08	0.63	0.51	0.65	0.76
C. D. (P=0.05)	0.63	0.51	NS	NS	NS	NS	2.93	2.38	NS	NS
Integrated nutrient management (F)										
F_1	7.20	8.01	4.75	5.56	7.50	7.70	23.40	24.45	46.62	47.58
F_2	8.29	9.18	6.22	6.38	8.11	8.20	30.45	31.80	49.39	50.29
F_3	9.33	10.15	6.43	6.64	8.47	8.61	33.61	34.95	52.05	52.86
F_4	5.93	6.92	4.19	5.20	7.11	7.21	22.16	23.39	44.71	45.65
S. Em±	0.19	0.23	0.07	0.07	0.15	0.17	0.34	0.61	0.59	0.60
C. D. (P=0.05)	0.95	1.18	0.34	0.37	0.76	0.85	1.68	3.03	2.96	2.98

TABLE 6
Green forage yield, Dry matter yield of pea and pea equivalent yield as influence by intercropping and INM

Treatments	GFY (q/ha)		DMY (q/ha)		Pea equivalent yield (q/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
C_1	-	-	-	-	357.11	382.35
C_2	230.57	247.82	33.00	38.62	1240.65	1458.57
C_3	85.96	92.30	11.91	13.78	649.70	743.73
C_4	111.11	119.39	15.70	18.03	767.45	878.41
S. Em±	1.81	1.85	0.22	0.35	12.92	11.80
C. D. (P=0.05)	8.35	8.52	1.04	1.62	39.11	35.71
Integrated nutrient management (F)						
F_1	130.83	136.62	18.23	20.81	672.45	776.55
F_2	152.64	167.20	22.21	25.94	813.90	930.10
F_3	158.92	175.01	23.43	27.93	881.32	1003.99
F_4	127.81	133.85	16.93	19.23	647.25	752.43
S. Em±	1.60	2.16	0.36	0.33	12.52	12.86
C. D. (P=0.05)	7.90	10.66	1.78	1.67	37.91	38.92

introduction of food-forage intercropping systems having component crop of oat and pea with planting geometry of 3:3 row proportion having considerable positive effect on the yield performance and addition of vermicompost can saved 50% of inorganic fertilizers.

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