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Effect of Intercropping Systems of Buckwheat and Lathyrus on Soil Physico-chemical Properties and Biological Efficiency in Rice Fallow Land under Organic Ecosystem

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ABSTRACT

The experiment was conducted at Assam Agricultural University, Jorhat with Buckwheat variety "Local" and Lathyrus variety "Ratan" during the *rabi* season of 2017-18 with the aim "Effect of intercropping systems of buckwheat and lathyrus on soil physico-chemical properties and biological efficiency in rice fallow land under organic ecosystem" in Randomized Block Design with three replication.The experiment revealed that soil was sandy loam with organic carbon (0.77 %) and initial nutrient content such as N (296.56 kg/ha), P_2O_5 (34.88 kg/ha) and K_2O (148.32 kg/ha). In respect of land equivalent ratio (LER), T_8 [Buckwheat + Lathyrus as grain (2:2)]; T_9 [Buckwheat + Lathyrus as fodder (2:2)] and T_5 [Buckwheat + Lathyrus as fodder (1:1)] was found best over the sole cropping. After harvest of the crops the soil health was not affected in respect of available N, P and K content and organic carbon. T_8 [Buckwheat + Lathyrus as grain (2:2)] was found to be the best in respect of, LER values indicating intercrop advantage, buckwheat equivalent yield, biological efficiency and B:C (2.48).

Keywords: NPK, Buckwheat, Lathyrus, Intercropping, Yield

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INTRODUCTION

The fertile lands remain fallow after harvest of rice crop. Only 16 % of the net cropped area is utilized for multiple cropping which suggests great scope for further utilization of the fallow land to increase income and employment generation of the farmers (FAOSTAT, 2020). While enhancing production and productivity of food grains in Assam, equal importance should be given to sustainable use of natural resources and suitable intensification of short duration crop like buckwheat, lathyrus etc. in rice fallow for efficient and adequate utilization of residual moisture after the harvest of paddy which offers a good scope for area expansion of these crops. Intercropping is the simultaneous growing of two or more species in the same field for a significant period of time. But not necessarily sowing or harvesting at the same time and describe intercropping as an eco-functional intensification practice which has been widely used to boost crop productivity and increase the resource utilization efficiency (Bandyopadhyay *et al.*, 2016; Kumar *et al.*, 2016). Buckwheat (*Fagopyrum esculentum* Moench) is an annual plant under family of polygonaceae, genus Fagopyrum. Buckwheat (*Fagopyrum spp*.) is one such underutilized crop, which has agronomic and nutritional benefits. *Fagopyrum esculentum* and *F. tataricum* are the two species cultivated in the Himalayas. Presently, cultivation of buckheat is concentrated in lower Brahmaputra Valley Zone (LBVZ) and Upper Brahmaputra Valley Zone (UBVZ) of Assam, mainly in Kokrajhar, Chirang and Sadia sub division of Tinsukia district (Rana *et al.*, 2012). The importance of buckwheat as baby food and organic honey production is increasing and there is a great opportunity for creation of market-oriented strategy. Grasspea (*Lathyrus sativus* L.) is an important legume crop grown in India as well as in Assam utilized for human food, animal feed and soil health improvement (Rana *et al.*, 2012). Grasspea has ability to resist drought, excess moisture, salinity, diseases, and insect pests. Therefore, an experiment was conducted to study the "Effect of intercropping systems of buckwheat and lathyrus on soil physico-chemical properties and biological efficiency in rice fallow land under organic ecosystem"

MATERIALS AND METHODS

The experiment was conducted at the organic block of Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat, Assam during *Rabi* season of 2017-18. The region is located at sub-tropical humid climate and hence humidity is high (avg. 81.96%). The experimental site was Sandy loam in texture with acidic soil reaction (pH-5.26), high in organic carbon (0.77%), medium in available nitrogen (296.56kg/ha) and potassium (148.23kg/ha) and low in available phosphorus (34.88kg/ha).

The experiment was carried out by using Randomized Block Design with 3 replications with 9 treatment combinations of intercropping of main crop buckwheat with *lathyrus* at different proportions viz. T_1: Sole buckwheat , T_2: Sole *lathyrus* as grain, T_3: Sole *lathyrus* as fodder, T_4: Buckwheat + *lathyrus*

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grain (1:1), T_5: Buckwheat + *lathyrus* fodder (1:1), T_6: Buckwheat + *lathyrus* as grain (2:1), T_7: Buckwheat + *lathyrus* as fodder (2:1), T_8 :Buckwheat + *lathyrus* as grain (2:2), T_9 :Buckwheat + *lathyrus* as fodder (2:2). The requirement of N of the main crop was applied through vermicompost one day ahead of sowing and incorporated into the soil (Fig. 1A-F). According to the treatment, seeds of buckwheat variety 'Local' and *lathyrus* variety 'Ratan' were sown @ 20 kg/ha and @ 25 kg/ha respectively, in furrows uniformly in replacement series at a depth of 4-5 cm keeping a distance of 25 cm between the furrows. In one plot (size 4.0 m × 3.0 m) there were twelve rows and accordingly as per treatment buckwheat row was replaced by *lathyrus* row by maintaining spacing at 25 cm. Then the seeds were covered with a thin layer of soil. Thinning was done after emergence whenever necessary. One light hoeing between the lines with garden hoe was also done at 25 days after sowing to control weeds and to loosen the soil. Harvesting of buckwheat was done plot-wise by uprooting the plant, when the cymes and seeds turned brown-blackish in colour. The seeds and the stover yield were recorded for both the crops. Lathyrus fodder was harvested when the crop was at small pod stage. Two border rows on either side of the plot and 50 cm row length from both the ends of the rows were discarded. The plants were cut by sickle at the base and tied into bundles separately for individual plot to measure individual plot yield (kg/plot).

Fig. 1A: A general view of the experiment

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Fig. 1D: Sole Lathyrus as gain

Fig. 1E: Flowering of lathyrus

Fig. 1F: Lathyrus fodder

RESULTS AND DISCUSSION

Seed yield, Stover yield, Biological yield of Buckwheat

Table 1 showed that the highest seed yield, stover yield and biological yield of buckwheat were recorded in sole buckwheat followed by buckwheat + lathyrus as grain (2:2). The higher yield attributes and yield of buckwheat under sole cropping followed by inter cropping might be due to less competition for space, sunlight, water and nutrients between buckwheat and component crop which gave higher growth parameters resulting in higher translocation of photosynthates from source to sink resulting in higher yield of buckwheat. Similar, finding was reported in coriander based intercropping systems (Gupta et al., 2011). bearing node and internode length is indeed scanty.

Table 1: Effect of intercropping of buckwheat and lathyrus on seed yield, stover yield, biological yield in (kg ha-1), harvest index (%) and buckwheat equivalent yield (kg ha-1) of buckwheat.

Treatments	Seed yield	Stover yield	Biological yield	Harvest index	Buckwheat equivalent yield
T_1:Sole buckwheat	1088.71	1402.58	2491.29	43.643	1088.71
T_2:Sole lathyrus as grain	-	-	-	-	384.67
T_3:Sole lathyrus as fodder	-	-	-	-	407.16
T_4:Buckwheat + lathyrus as grain (1:1)	529.73	618.88	1,148.62	48.180	729.94
T_5:Buckwheat + lathyrus as fodder (1:1)	677.03	660.55	1337.58	50.717	734.91
T_6:Buckwheat+ lathyrus as grain(2:1)	661.74	624.44	1,286.18	51.357	783.86
T_7 : Buckwheat + lathyrus as fodder (2:1)	710.05	742.77	1,452.82	48.680	748.45
T_8: Buckwheat + lathyrus as grain (2:2)	836.97	908.33	1,745.30	47.940	1,029.79
T_9 : Buckwheat + lathyrus as fodder (2:2)	739.43	755.83	1,495.26	49.527	799.29
SEm(±)	49.99	72.41	94.78	2.689	46.54
CD(P=0.05)	155.73	225.58	295.29	NS	140.73

Seed yield, Stover yield and Biological Yield of Lathyrus

Table 2 showed that the highest seed yield was recorded in sole lathyrus as grain followed by buckwheat + lathyrus as grain (1:1). Similarly, the highest stover yield and biological yield of lathyrus were recorded in sole lathyrus as grain followed by buckwheat + lathyrus as grain (2:2). Among the intercrops studied, the grain yield was higher when they were grown as sole crop than the grain yield obtained in intercropping system. Similar, finding was reported in grain amaranth based intercropping system (Kumar and Murthy, 2017).

Table 2: Effect of intercropping of buckwheat and lathyrus on seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) , biological yield(Kg ha^{-1}) and harvest index of lathyrus

Treatments	Seed yield	Stover yield	Biological yield	Harvest index
T_1: Sole buckwheat	-	-	-	-
T_2:Sole lathyrus as grain	465.34	974.70	1440.04	32.31
T_3:Sole lathyrus as fodder	-	-	-	-
T_4:Buckwheat + lathyrus as grain (1:1)	234.14	473.83	708.01	33.07
T_5:Buckwheat+lathyrus as fodder	-	-	-	-
T6: Buckwheat + lathyrus as grain (2:1)	155.93	325.72	481.65	32.37
T7: Buckwheat + lathyrus as fodder (2:1)	-	-	-	-
T8: Buckwheat + lathyrus as grain (2:2)	233.47	516.33	749.79	31.13
T9: Buckwheat + lathyrus as fodder (2:2)	-	-	-	-
SEm(±)	6.87	6.08	9.98	0.46
CD(P=0.05)	24.24	21.432	35.194	NS

Harvest index of Buckwheat

Table 1 revealed that the harvest index of buckwheat had failed to differ significantly due to the different combinations of intercrop and sole cropping. The highest harvest index was recorded in buckwheat + lathyrus (G) (2:1) (51.36 %) followed by buckwheat + lathyrus (F) (1:1) (50.72 %) and buckwheat + lathyrus (F) (2:2) (49.53 %).

Harvest index of Lathyrus

Table 2 revealed that the harvest index of lathyrus had failed to differ significantly due to the different combinations of intercrop and sole cropping. The highest harvest index was recorded in buckwheat + lathyrus (G) (1:1) (33.07%) followed by buckwheat + lathyrus (G) (2:1) (32.37%) and sole lathyrus (G) (2:2) (32.31 %).

Buckwheat equivalent yield

Table 1 showed that the buckwheat equivalent yield was found to be significant due to the different combinations of intercrops and sole cropping. The highest buckwheat equivalent yield was recorded in sole cropping (1088.71 kg ha-1) and it was statistically at par with buckwheat + lathyrus (G) (2:2) (1029.79 kg ha-1), the lowest buckwheat equivalent yield was recorded in sole lathyrus (F) (407.16 kg ha-1) and it was statistically at par with sole lathyrus (G) (384.67 kg ha-1).

Biological efficiencies

Table 3 showed that the greater LER value was associated with buckwheat that was intercropped with lathyrus as grain (2:2). The highest (1.27) LER was recorded in buckwheat + lathyrus as grain (2:2) followed by buckwheat + lathyrus as fodder (2:2) (1.16). It indicates that LER of 1.27 can be interpreted as 27% greater yield for intercropping or as a 27% greater area requirement for the monocrop system. Higher LER in intercropping treatments indicated yield advantage over monocropping due to better land utilization (Mishra, 2019). The highest K value was recorded in buckwheat + lathyrus as grain (2:2) (3.32) followed by buckwheat + lathyrus as fodder (2:2) (1.92). It indicates the yield advantage whether a species or crop when grown in mixed population has produced more yield than expected in pure stand of crop.

Table 3: Effect of intercropping system on Land Equivalent Ratio and Relative Crowding Coefficient

Treatments	Land Equivalent Ratio	Relative Crowding Coefficient		
		Kab	Kba	K
T1:Sole Buckwheat	1.00	-	-	-
T2:Sole lathyrus as grain	1.00	-	-	-
T3:Sole lathyrus as fodder	1.00	-	-	-
T4:Buckwheat +lathyrus as grain (1:1)	0.99	0.95	1.01	0.96
T5:Buckwheat+lathyrus as fodder(1:1)	1.09	1.64	0.92	1.51
T6:Buckwheat +lathyrus as grain (2:1)	0.94	0.77	1.00	0.77
T7:Buckwheat +lathyrus as fodder(2:1)	0.96	0.94	0.91	0.86
T8:Buckwheat+lathyrus as grain(2:2)	1.27	3.32	1.00	3.32
T9:Buckwheat+lathyrus as fodder(2:2)	1.16	2.11	0.91	1.92

Total NPK uptake by buckwheat and lathyrus as grain and fodder

Table 4 showed that total uptake of nitrogen by buckwheat, lathyrus as grain and lathyrus fodder was recorded in sole lathyrus as fodder followed by buckwheat + lathyrus as fodder (2:2). The highest total phosphorus uptake by buckwheat, lathyrus as grain and lathyrus fodder was recorded in sole buckwheat followed by buckwheat + lathyrus as grain (2:2). The highest total potassium uptake by buckwheat, lathyrus as grain and lathyrus fodder was recorded in sole lathyrus as grain followed by buckwheat + lathyrus as grain (2:2). As compared to inter cropping system, highest nutrient uptake by buckwheat or lathyrus was recorded in sole cropping it might be due to higher dry matter production by crop under sole cropping as compared to inter cropping. Collateral findings regarding this fact have been found under peas and oats based cropping system (Jannoura et al., 2014)

Table 4: Effect of intercropping of buckwheat and lathyrus on NPK total uptake (kg ha-1) of buckwheat , lathyrus as grain & lathyrus fodder

Treatments	NPK uptake		
	N	P	K
T1 : Sole buckwheat	26.40	8.72	12.93
T2 : Sole lathyrus as grain	21.16	2.20	36.71
T3 : Sole lathyrus as fodder	38.91	2.46	14.38
T4 : Buckwheat + lathyrus as grain (1:1)	24.65	5.26	24.48
T5 : Buckwheat + lathyrus as fodder (1:1)	33.43	5.92	14.11
T6 : Buckwheat + lathyrus as grain (2:1)	23.40	5.43	19.30
T7 : Buckwheat + lathyrus as fodder (2:1)	27.94	5.97	12.19
T8 : Buckwheat + lathyrus as grain (2:2)	30.70	7.43	27.83
T9 : Buckwheat + lathyrus as fodder (2:2)	34.89	6.60	14.99
SEm (±)	1.29	0.26	0.64
CD (P=0.05)	3.89	0.81	1.96

Soil

Table 5 revealed that the effect of sole cropping and intercropping of buckwheat and lathyrus on soil pH and organic carbon (%) in soil after harvest of crop as influenced by intercropping system .The different sole and intercropping of buckwheat and lathyrus could not bring any significant changes in soil pH value and organic carbon content in soil.

Available N, P_2O_5 and K_2O

Table 5 showed that the effect of sole cropping and intercropping of buckwheat and lathyrus on available N, P_2O_5 and K_2O (kg/ha) in soil after harvest of crop as influenced by intercropping system .The different sole and intercropping of buckwheat and lathyrus could not bring any significant changes in available N, P_2O_5 and K_2O contents in soil.

Table 5: Effect of intercropping of buckwheat and lathyrus on pH, OC (%) and available N, P_2O_5 and K_2O content (kg ha^{-1}) in soil after harvest of crop

Treatments	pH	OC	N	P_2O_5	K_2O
T1 : Sole buckwheat	5.47	0.74	289.50	51.81	157.84
T2 : Sole lathyrus as grain	5.53	0.76	291.52	53.98	150.30
T3 : Sole lathyrus as fodder	5.53	0.76	285.20	53.84	157.19
T4 : Buckwheat + lathyrus as grain (1:1)	5.50	0.74	291.06	53.21	154.08
T5 : Buckwheat + lathyrus as fodder (1:1)	5.64	0.76	287.07	52.67	157.39
T6 : Buckwheat + lathyrus as grain (2:1)	5.54	0.75	289.98	52.70	155.12
T7 : Buckwheat + lathyrus as fodder (2:1)	5.56	0.73	288.84	52.52	157.96
T8 : Buckwheat + lathyrus as grain (2:2)	5.56	0.73	287.72	51.99	152.32
T9 : Buckwheat + lathyrus as fodder (2:2)	5.55	0.74	286.10	52.49	156.93
SEm (±)	0.06	0.01	2.19	0.74	2.72
CD (P=0.05)	NS	NS	NS	NS	NS

Economics of buckwheat and lathyrus under sole and intercropping system

Table 6 showed that cost of production, gross return and B:C ratio. Among different treatment highest cost of cultivation (25,100.00) was recorded in sole buckwheat. Among the intercroppings the highest gross return (77,237.75.00), net return (55,024.75.00) and B:C (2.48) were obtained by buckwheat + lathyrus as (G) in 2:2. The increase in gross and net return and benefit: cost ratio (B: C ratio) might be due to positive effect of this treatment on growth and yield attributes. It was conformity with the findings under rapeseed (*Brassica rapa* var. *dichotoma*) based intercropping systems (Ao *et al*., 2016)cant changes in available N, P_2O_5 and K_2O contents in soil.

Table 6: Economics of intercropping of buckwheat and lathyrus

TREATMENTS	Cost of cultivation ($Rs.ha^{-1}$)	Gross return ($Rs.ha^{-1}$)	Net return ($Rs.ha^{-1}$)	B:C ratio
T1 : Sole buckwheat	25,100.00	81,653.00	56,553.00	2.25
T2 : Sole lathyrus as grain	20,820.00	28,850.25	8,030.25	0.39
T3 : Sole lathyrus as fodder	19,820.00	30,537.00	10,717.00	0.54
T4 : Buckwheat + lathyrus as grain (1:1)	21,810.00	54,220.75	32,410.75	1.49
T5 : Buckwheat + lathyrus as fodder (1:1)	21,710.00	55,118.50	33,408.50	1.54
T6 : Buckwheat + lathyrus as grain (2:1)	22,766.00	58,789.75	36,023.75	1.58
T7 : Buckwheat + lathyrus as fodder (2:1)	22,666.00	56,134.25	33,468.25	1.48
T8 : Buckwheat + lathyrus as grain (2:2)	22,210.00	77,234.75	55,024.75	2.48
T9 : Buckwheat + lathyrus as fodder (2:2)	21,710.00	59,946.75	38,236.75	1.76

CONCLUSION

Based on the results of the experiment it can be concluded that among the sole cropping treatments, buckwheat was found to be the best crop under rice fallow land organic ecosystem. As a whole intercropping of buckwheat with lathyrus as grain in 2:2 ratio found to be the best in respect of buckwheat equivalent yield, biological efficiency and economic point of view. The different sole and intercropping of buckwheat and lathyrus could not bring any significant changes in soil pH value, organic carbon content, available N, P2O5 and K2O contents in soil.

There is need for further research to generate more useful information on regarding intercropping of Buckwheat and Lathyrus under organic ecosystem.

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