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Enhancement of farm productivity through intercropping of vegetables, pulse and oilseed crops with wheat at Jamuna Char area of Islampur in Jamalpur District

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ABSTRACT

An experiment was conducted during winter cropping (*rabi*) season at the farmer's field of Jamuna Char area of Gutail, Islampur in Jamalpur district of Bangladesh. The experiment comprised of 30 cm × continuous planting systems of wheat and the intercrops such as mustard, garden pea; grass pea, spinach, lentil and chickpea were grown with wheat following randomized complete block design in three replications. There were seven treatment combinations *viz.* T_1= Sole wheat (100%) (30 cm × continuous), T_2= 100% wheat + one row mustard between two rows of wheat, T_3= 100% wheat + one row garden pea between two rows of wheat, T_4= 100% wheat + one row grass pea between two rows of wheat, T_5= 100% wheat + one row lentil between two rows of wheat, T_6= 100% wheat + one row spinach between two rows of wheat, T_7= 100% wheat + one row chick pea between two rows of wheat. From the experiment it revealed that intercropping of vegetables and pulses with wheat is more profitable than sole cropping of wheat. Wheat yield differed significantly among the different intercropping combinations. The maximum and minimum wheat yields 3.80 t ha^{-1} and 2.80 t ha^{-1} were obtained from sole wheat and wheat intercropped with mustard combinations, respectively. Wheat equivalent yields in the intercrops ranged from 3.80-5.38 t ha^{-1}. The maximum cost of cultivation Tk. 82,540 ha^{-1} was obtained from wheat + chick pea intercropping system while the minimum cost of cultivation Tk. 66,960 ha^{-1} was obtained from sole wheat planting system. The treatment wheat + chickpea intercropping system produced the maximum gross return Tk. 1,78,950 ha^{-1} followed by Tk. 1,72,600 ha^{-1} in wheat + garden pea and Tk. 1,72,000 ha^{-1} in wheat + grass pea intercropping system respectively while the minimum gross return Tk. 1,31,100 ha^{-1} from wheat + mustard intercropping system. The maximum gross margin Tk. 97,460 ha^{-1} was obtained from the wheat + grass pea intercropping system followed by Tk. 96,410 ha^{-1} and Tk. 91,660 ha^{-1} was obtained from wheat + chickpea and wheat + garden pea intercropping systems respectively. Wheat + grass pea intercropping system contribute the maximum benefit cost ratio (2.30) followed by wheat + chick pea (2.20), wheat + garden pea (2.10) and wheat + spinach (2.10).

Introduction

Bangladesh is the world's eighth largest country in terms of population. About 65% of the population depends on the farming sector for their livelihood. Cultivable land is declining by one percent of cultivable land area in every year due to establishment of new road and highways, buildings, industries, markets etc. (BBS, 2011). On the other hand, due to geographical location Bangladesh is very much vulnerable and is in the risky position to climate change of the world. These will cause a serious shortage of cultivable land for crop production and a severe food shortage to feed her people in near future. Under this situation, there is a vast scope of growing more crops in unutilized char lands. The inventory of main river char lands estimated their total area at 8,444 km^2 or almost 6% of Bangladesh (FAP 16/19, 1993a). In 1992-93, this comprised 33% unprotected main land and 67% char land. So introduction of suitable high yielding varieties of *rabi* crops such as wheat, pulse, oil seed and vegetable enabling to grow in the drought and less soil moisture condition eventually would increase farm productivity and ensure food security as a whole which will reduce the poverty level of the poor farmers in char land areas. Farmers cultivate wheat as a sole crop in all over the country but it is a low yielded crop compare to *boro* rice. As a result the farmers discourage themselves to cultivate wheat. Under this situation short duration *rabi* vegetables, leguminous and oil seed crops can be easily accommodated as intercrop between the wheat rows.

Intercropping is a system of management of crop which involves growing of two or more dissimilar crop species or varieties simultaneously in distinct row combination on the same piece of land (Katyayan, 2005). This technique has been found to have many advantages; mainly efficiency of resource utilization can be increased with intercropping (Tilman et al. 2002; Gao et al. 2014; Nasri et al. 2014). This practice gives increased and more stable yields, better nutrient recycling in the soil, better control of weeds, pests and diseases.

The advantages of intercropping are risk minimization, effective use of available resources, efficient use of labour, increased crop productivity, erosion control and food security (Bekunda & Woomer, 1996; Jodha, 1979; Owuor et al. 2002). Cereals and legumes both for forage and grain, are the most common intercrops. There has been an increase in grower interest in using intercropping since it could reduce management inputs that result in sustainable systems more efficiently using an even potentially replenishing natural resources used during crop production for long term management of farmland. The main advantage of the legume-cereal intercrop is the input of nitrogen to the system by the fixation of atmospheric N_2 by the legume, which may contribute to an increased quality of the intercrop components.

Crop production enhancement in the char areas depends on growing dry land *rabi* crops on ridges cultivation of crops *viz.* wheat, HYV mustard, improved *rabi* pulses, and early *rabi* vegetables. Among the different *rabi* crops wheat is the second most cereals after rice. On the other hand average national yield of *boro* is higher than of wheat. The water requirement for *boro* rice cultivation in fine loamy soil was 97-163 cm. Sandy loam soil 81-170 cm and 82-126 cm (Hossain, 2008), respectively. Silt loam soil the water requirement for wheat cultivation was 13.7-22.5 cm (Karim, 1999), respectively. This high irrigation requirement for *boro* is economically fashionable to the farmers. Nevertheless, a large scale farmers' show the negative impact on wheat cultivation only a few number of farmers mostly grow wheat as a sole crop in upland under *rainfed* condition. As a result the wheat area is gradually decreased day by day and the farmers get the poor yield. Now a day increasing irrigation facilities provides an opportunity to increase the productivity of this ecosystem.

Vegetables are very important group of crops and they constitute a major part of diet contributing vitamins, minerals and protein. They also make our diet more palatable and variable (Tsou, 1992). Intercropping of high value short duration *rabi* vegetables with wheat might be an option for increasing the productivity of char land areas. Spinach, edible poded peas are the short duration crops grown in early *rabi* season. In an intercrop system between cereals, beans and peas, there has been increased yield presumably by the transfer of biologically fixed nitrogen from the roots of legume to the root zone of the companion crop (Akyempong et al. 1999; Gold et al. 1999; Ndungu *et al.* 2003; Reddy & Willey, 1981). To optimize cropping system benefits from pulse crops (legume), it is important to understand their effects on subsequent crops. Nitrogen additions due to pulse crops have also been reported to increase productivity of succeeding cereal crops (Beckie & Brandt, 1997). Pulse crops have also been reported to reduce cereal disease incidence (Beckie & Brandt, 1997). Pulse crops can yield handsome under drought/moisture stress condition and fix biological nitrogen from atmosphere that can improve soil health. This improves physical, biological and chemical properties of the soil and increase yield of the subsequent crops. Pulses are also considered as poor man's meat as it rich in protein. Considering the facts, cultivation of more pulses in the char areas would contribute a lot for food security, social protection and health of the distressed char farmers. More over Farmers are cultivating wheat in a small scale as monoculture at present in the char areas. Introduction of intercropping system with wheat may lead to judicial use of natural resources, weed suppression and food production. As a result it will bring the God blessing for char areas people and will increase economic return which will encourage the farmers' of char areas for wheat cultivation. Studies on the productivity and profitability of intercropping of vegetables, pulse and oil seed crops with wheat have not been reported. Therefore, this study was undertaken to enhancement the farm productivity of char areas farmers' through intercropping of pulse, vegetables and oil seed crop with wheat at a simple planting geometry.

Materials and Methods

Experimental location

The experiment was conducted at the farmer's field of Jamuna Char area of Gutail, Islampur in Jamalpur district of Bangladesh following randomized complete block design with three replications. The experimental site was of medium high land belonging to the agro-ecological zone Old Brahmaputra Floodplain under Agro-Ecological Zone 9 (UNDP & FAO, 1988). The experimental site is located at about 40 km North-West from Jamalpur district town.

Planting materials

Wheat (*Triticum aestivum* var. BARI Gom 26), garden pea (*Pisum sativum* var. BARI motorshuti 3), grass pea (*Lathyrus sativus* var. BARI Khesari 2), lentil (*Lens culinaris* var. BARI masur 7), chickpea (Cicer arietinum var. BARI Chola 9) and mustard (*Brassica napus* var. BARI Sarisha 14) were used in this experiment. For spinach local variety was used as there is no modern variety so far released by any organization in our country. Seed rates were 100, 30, 45, 7, 45 and 13 kg ha^{-1} of wheat, lentil, chickpea, mustard; garden pea and grass pea respectively were used in this study.

Crop cultivation

The main crop wheat was planted at 30 cm × continuous planting system to accommodate the component crop between two rows of wheat. Intercrops such as mustard, garden pea, grass pea, lentil, spinach and chickpea were included in the experiment. As a result the whole treatment combination was T_1= Sole wheat (100%) (30 cm × continuous), T_2= 100% wheat + one row mustard in between two rows of wheat, T_3= 100% wheat + one row garden pea in between two rows of wheat, T_4= 100% wheat + one row grass pea in between two

rows of wheat, T_5= 100% wheat + one row lentil in between two rows of wheat, T_6= 100% wheat + one row spinach in between two rows of wheat, T_7= 100% wheat + one row chick pea in between two rows of wheat.

The unit plot size was 5 m × 3 m. The sole crop wheat was sown on 05 November 2014 and on the same day the component crops were sown between two rows of wheat. Soil sample of the experimental plot was collected before set-up the experiment and analyzed in the laboratory. Texture of the soil was sandy loam to silt loam having pH 6.6 containing 1.79% organic matter. Fertilizers were applied in sole and intercrop plots at the rate of 45-15-36-7.5-1.0-0.8 kg ha^{-1} N-P-K-S-Zn-B, respectively in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid (FRG, 2012). For intercrops no additional fertilizers were applied. Two-third urea and all other fertilizers were applied as basal during final land preparation. The rest one-third urea was top dressed after first irrigation. Gap filling was done where seeds were not germinated immediately after completion of 80% seedling emergence in the plot. This was done to maintain the optimum plant population. Two weeding was done in sole wheat. First was done at 30 and second was done at 45 days after sowing (DAS). Weeds remained close to the wheat plants were removed by *nirani*. In case of all intercropping systems second weeding was not possible. On the basis of field conditions two irrigations was applied at 25 and 60 days after sowing. Flood irrigation was given at all times and after irrigation excess water was drained out as soon as possible.

Crop harvesting and data calculation

The sole crop wheat was harvested on 5th March, 2016 when at least 80% spikelet of each plot attained yellowing color maturity was recorded as days to maturity. Intercrops were harvested at different dates depending on their edible stages and maturity. Spinach, garden pea and grass pea were harvested two times while lentil, mustard and chickpea were harvested once a time depending on their maturity. Spinach was harvested at two times at 30 and 40 days after sowing while grass pea was harvested at 40 and 55 days after sowing as a vegetables and green forage. Weight of fresh garden pea, spinach and grass pea obtained from the whole plots at different harvests were recorded and summed up at the end of the crop's life. The relative yield was obtained by dividing the intercrop yield of a crop with the respective sole crop yield of that crop using the formula (Dewit & Vander Bergh, 1965).

$$\text{The relative yield of a crop} = \frac{\text{Yield of components crop}}{\text{Yield of sole crop}}$$

Wheat equivalent yield was calculated by converting the yield of mustard, garden pea, lentil, grass pea, chick pea, and spinach into the yield of wheat on the basis of prevailing market prices using the formula of Anjaneyulu et al. (1982).

Wheat equivalent yield = Yield of wheat + Yield of intercrop × price of intercrop / Price of wheat. Y_w= Yield of Wheat P_w= Sale price of wheat, Y_{int} = Yield of intercrop (mustard, garden pea, lentil, grass pea, chick pea, spinach) and P_{int}= Sale price of intercrop.

In case of economic analysis material and non-material input cost were considered for calculation of the total cost of cultivation. Besides, the gross return was calculated on the basis local market of Jamalpur prices of grain, vegetables and forage during the harvesting period. Yield and yield contributing characters of wheat were collected from ten randomly selected plants prior to harvest. Grain yield data was collected from whole plot basis and converted to t ha^{-1} at 12% moisture.

Statistical analysis

Collected data were analyzed statistically following analysis of variance technique as per design of the experiment. Computer package programs MSTAT and MS-Excel were used for statistical analysis. Mean separation was done at 5% level of probability following Least Significant Difference Test (LSD).

Results and Discussion

Effect of intercropping vegetables, pulse and oilseed crop on growth and yield attributes of wheat

Plant height of wheat did not differ significantly among the intercrop combinations (Table 1). The results indicated that plant was taller in the plots where wheat was sole followed by intercropped with grass pea and lentil. This might be due to more moisture conservation in the soil as these intercrops cover the soil more than the others. Generally, plants were shorter in the treatments when wheat was intercropped with mustard. It might be due to shading effect of mustard on wheat.

Number of spike m^{-2} differed significantly among the intercrop combinations. The maximum number of spike m^{-2} was found in sole wheat followed by intercropped with garden pea and grass pea (Table 1). Intercropping of wheat with lentil, spinach and chickpea produced the moderate number of spikes m^{-2}. Intercropping of wheat with mustard produced the shortest spike length whereas garden pea intercropped with wheat produced longest spike followed by other intercropped. The sole wheat produced the maximum number of spikelet $spike^{-1}$ followed by wheat intercropped with lentil and grass pea. Intercropping of wheat with garden pea, chickpea and spinach produced the moderate number of spikelet $spike^{-1}$.

Number of grain $spike^{-1}$ and 1000-grain weight did not differ significantly among the different intercropping systems. But numerically wheat intercropped with mustard produced the minimum number of grain $spike^{-1}$ and wheat intercropped with chickpea produced the maximum number of grain $spike^{-1}$. Khan et al. (2005) carried out field

experiments to study effect of lentil, rapeseed and chickpea in different proportion on yield and yield components of wheat. They concluded that number of grain spike^{-1} of wheat was higher when wheat was intercropped with chickpea with proportion of 1:1. Numerically wheat intercropping with garden pea produced the maximum 1000-grain weight. Others intercropping systems produced the numerically similar number of grain spike^{-1} and 1000-grain weight.

Effect of intercropping vegetables, pulse and oilseed crop on grain yield, WEY and relative yield of wheat

The results revealed that grain yield of wheat differed significantly among the intercrop combinations (Table 1). This could be attributed to the fact that intercrops used in the study significantly influenced the yield of wheat. Among the intercropping systems the treatment wheat intercropped with mustard produced the minimum grain yield 2.82 t ha^{-1}. Similar finding was revealed by Srivastava & Bohra, (2006) who stated that in various wheat-mustard intercropping, the lowest wheat yield was achieved at highest mustard population and vice versa. Wheat intercropped with chickpea produced the 3.57 t ha^{-1} yield. Mondal et al. (1991) concluded that wheat and chickpea intercropping gave the higher yield of wheat as well as water use efficiency than wheat and rapeseed intercropping. Also Khan et al. (2005) carried out field experiments to study effect of lentil, rapeseed and chickpea in different proportion of yield and yield components of wheat. They concluded that grain yield of wheat was higher when wheat was intercropped with chickpea with proportion of 1:1. Generally, grain yield was higher in most of the intercropping systems when wheat was planted in spinach, grass pea and lentil. The sole wheat produced the maximum seed yield. Wheat intercropped with mustard produced the minimum seed yield. It might be due to the more interplant competition during the whole crop growing period. Generally sole wheat provide the comparatively low yield than its potential yield, might be due to the more line spacing than standard.

Relative yield determines competitive ability of component crops in intercropping system. Greater value of relative yield showed more competitive ability in intercrop situation compared to its monoculture (Juskiw et al. 2000). The relative yields of wheat were 0.97, 0.87, and 0.54 when wheat was intercropped with spinach, grass pea and garden pea, respectively (Table 1). This indicates that wheat yield was reduced by 3%, 13%, and 46% of sole crop when it was intercropped with spinach, grass pea and garden pea, respectively. The lower relative yield of wheat in intercropping indicated that the crop faced competition for space, nutrients, light, and water with vegetables. The findings are in agreement with that of Singh (1993) and Rahman (1999).

All the intercropped combinations showed higher wheat equivalent yield than sole wheat in all cases. Among the treatments, the highest wheat equivalent yield (5.38 t ha^{-1}) was obtained from wheat + garden pea intercrop combination followed by wheat + chickpea and wheat + grass pea intercropping combination (Table 1). The lowest wheat equivalent yield (4.73 t ha^{-1}) was obtained from wheat + mustard intercrop combination. Although wheat yield was 11.8, 7.9, 10.0, 6.6 and 6.1% lower than sole crop when it was intercropped with garden pea, grass pea, lentil, spinach and chickpea, respectively. But wheat equivalent yield from wheat + garden pea, wheat + grass pea, wheat + lentil, wheat + spinach and wheat + chickpea intercropped combination showed 29.4, 27.1, 23.1, 22 and 29% higher yield advantage over the sole wheat, respectively. This result showed that wheat + garden pea, wheat + grass pea and wheat + chickpea intercrop combination was perfect in respect of total yield advantage.

Yield of inter crops and economic performance

Intercrops yield varied among the different combinations might be due to the variations of different intercrops species, variation of population, canopy structure, and availability of other growth resources like light, water, nutrients and survival capacity with main crop. Mustard produced the seed yield 0.81 t ha^{-1} when intercropped with wheat (Table 2). Lentil population was poor in the intercropping systems due to excess moisture in the soil. As result, it produced the comparatively low yield. Another leguminous crop chick pea produced the comparatively lower yield than potential yield. All vegetables performed better in intercropping system with wheat.

From the experiment it revealed that the maximum cost of cultivation was found Tk. 82,540 ha^{-1} in wheat + chick pea intercropping system while the minimum cost of cultivation was found in Tk. 66,960 ha^{-1} in sole wheat planting system. The wheat + chickpea intercropping system produced the maximum gross return Tk. 1,78,950 ha^{-1} followed by Tk. 1,72,600 ha^{-1} in wheat + garden pea and Tk. 1,72,000 ha^{-1} in wheat + grass pea intercropping systems while the minimum gross return Tk. 1,31,100 ha^{-1} was obtained from wheat + mustard intercropping system. The maximum gross margin Tk. 97,460 ha^{-1} was obtained from wheat + grass pea intercropping system followed by wheat + chickpea (Tk. 96,410 ha^{-1}) and wheat + garden pea (Tk. 91,660 ha^{-1}) intercropping systems, respectively. The maximum benefit cost ratio (2.30) was obtained from wheat intercropped with grass pea. The minimum benefit cost ratio (1.70) was obtained from intercropping of wheat with mustard but Verma et al. (1997) reported that maximum net return, BCR and LER in intercropping of wheat and Indian mustard.

Table 1. Yield and yield attributes of wheat intercropped with vegetables, pulses and oil seed crop at Jamuna Char area of Islampur in Jamalpur District during *rabi* 2014-2015.

Intercropping	Plant height (cm)	No. of spike m^{-2}	Length of spike (cm)	No. of spikelet $spike^{-1}$	No. of grain $spike^{-1}$	1000-grain wt (g)	Grain yield (t ha^{-1})	Relative yield of wheat	WEY (t/ha)
Sole wheat	83.5	348.0	8.85	19.9	40.1	41.0	3.80	1.00	3.80
Wheat +Mustard	80.5	330.0	7.10	17.0	38.8	39.0	2.82	0.21	4.73
Wheat+Gardenpea	82.5	345.0	9.10	18.3	39.1	42.5	3.35	0.54	5.38
Wheat +Grass pea	83.3	342.3	8.60	19.7	39.0	42.0	3.50	0.87	5.21
Wheat +Lentil	83.7	339.0	8.20	19.6	36.0	41.0	3.40	0.13	4.94
Wheat+Spinach	81.5	338.0	8.30	18.0	37.0	41.3	3.55	0.97	4.86
Wheat +Chick pea	81.6	339.3	8.00	18.3	41.0	41.0	3.57	0.32	5.34
CV (%)	4.54	6.45	7.21	7.39	4.5	4.83	**	--	--
LS	NS	**	*	*	NS	NS	**	--	--
$LSD_{0.05}$	--	8.75	1.06	2.41	--	--	0.32	--	--

LS= Level of significance, WEY= Wheat Equivalent Yield

Table 2. Wheat yield, intercropped yield and economic performance of intercropping different vegetables, pulse and oil seed crop with wheat at Jamuna Char area of Islampur in Jamalpur District during *rabi* 2014-2015.

Intercropping	Yield (t ha^{-1})		Total cost of cultivation (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
	Wheat yield	Intercropped yield				
Sole wheat	3.80	--	66,960	1,33,000	66,040	2.0
Wheat +Mustard	2.82	0.81	78,380	1,31,100	52,720	1.7
Wheat+Gardenpea	3.35	2.05	80,940	1,72,600	91,660	2.1
Wheat +Grass pea	3.50	3.30	74,540	1,72,000	97,460	2.3
Wheat +Lentil	3.40	0.50	81,820	1,59,000	77,180	1.9
Wheat+Spinach	3.55	3.70	75,440	1,61,250	85,810	2.1
Wheat +Chick pea	3.57	1.20	82,540	1,78,950	96,410	2.2

Selling price: Wheat grain Tk 35.0 kg^{-1}; Mustard Tk. 40 kg^{-1}; Garden pea- Tk 27.00 kg^{-1}; Grasspea- Tk. 15.00 kg^{-1}; Spinach- Tk 10.00 kg^{-1}; Lentil Tk. 80 kg^{-1}, Chickpea Tk. 45 kg^{-1}.

Conclusion

From these results, it revealed that wheat grown as intercrop with vegetables and pulse like garden pea, grass pea, spinach and chickpea may be profitable than sole wheat. Intercropping increased total productivity which is expressed in WEY. All the intercrop combinations gave higher WEY than sole wheat but from economic point of view mustard and lentil intercropping with wheat were found non-profitable while others combination found little bit profitable. The results finally suggest the possibility of obtaining a reasonably good yield and profitable economic return from intercropping wheat with grass pea intercropping with wheat could be profitable for char areas farmers.

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