Performance of Mungbean+Leafy Vegetables Intercropping in a Floating Garden

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ABSTRACT

An experiment was conducted to find out the suitable crop combination for increasing total productivity and net return through legume+vegetables intercropping system in a floating garden. Seven treatments viz., mungbean (monocrop), pechay (monocrop), upland kangkong (monocrop), lettuce (monocrop), mungbean + lettuce, mungbean + upland kangkong and mungbean + pechay were used in the study. Results showed that different intercropping combination did not influence the agronomic and yield components of mungbean which include the days to flowering, plant height, pod length and weight (g) of 100 seeds. No significant differences were also observed in the plant height of vegetables and the weight of pechay in mono and intercropping scheme. The intercropping system varied significantly in the weight (g) of 100 seeds and yield (kg/ha) of mungbean, weight plant^{-1} of lettuce and kangkong and herbage yield of all leafy vegetables. The yield of mungbean was comparatively lower when intercropped with vegetables. However, total productivity was higher due to additional yield of leafy vegetables. Among the intercrop combinations, mungbean+kangkong intercropping was the most feasible and profitable because it obtained the highest gross income, net income, and return on investment.

Key words- floating garden, intercropping, mungbean, vegetables

INTRODUCTION

Mungbean (*Vigna radiata* L.) is popularly known in the Philippines as mungo. It is an annual grain legume and is mainly used as human food. It is widely spread in Asia and an important component of many major cropping systems (Lambrides, *et al.*, 2006). It is one of the most important pulse crops for protein supplement in subtropical zones of the world. It is a good source of minerals such as calcium and sodium. Dried mungbean seeds are high in vitamins A & B while the sprouted mungbeans are rich in vitamins B & C (www.bpre.gov.ph/phindustry/mungbean.htm accessed 2009). It also contains 51% carbohydrate, 24–26% protein and 4% mineral (Afzal *et al*., 2008). Fresh or dry mungbean seed can be used as a whole or may be processed to bread, noodles, porridge, soups, snacks or even ice-cream (Mogotsi, 2006). Besides providing protein in the diet, mungbean has the remarkable quality of helping the symbiotic root rhizobia to fix atmospheric nitrogen and improves soil fertility (Anjum *et al*., 2006). It can also be used as intercrop or a cover crop due to its short growing period (Bhatty, 2000 and Ashour, 1991).

In developing countries intensive and efficient use of available lands and in land waters for more food production is needed. Fishpond sediments are important resource enriched with plant nutrients and organic matter which have a vital role in maintaining or

improving soil quality. They are the key quality factors that determine the degree of nutrient retention in soil. Pond sediments are rich in N, P, and K, and other macro and micronutrients that will provide the nutrient requirement of a crop. The crops utilize nutrients in sediment, thereby reducing possibilities for environmental pollution. Thus, it can be used for a successful integration between aquaculture and agriculture (Rahman, and Ranmukhaarachchi, 2003).

Intercropping is an intensive cropping system that is intended to increase production per unit area and time (Adhikary *et al*., 2005). It is more productive system and a less risky technology (Kamanga *et al*., 2010). It helps in the effective utilization of land, soil moisture, nutrients and solar radiation. This is brought about by choosing appropriate crops of varying morpho-physiological nature and planning their planting geometry to reduce mutual competition for resources (Gurigbal, 2010). Flexibility, maximization of profit, minimization of risk, soil conservation and soil fertility improvement are some of the principal reasons for smallholder farmers to intercrop their farms/crops (Matusso *et al*., 2012). Furthermore, it offers the possibility of yield advantage relative to sole cropping through yield stability (Bhatti *et al*., 2005). Eventhough vegetables are non-nitrogen fixers, they can also be suitable as intercrops because of their high profitability and higher yields. Utilizing fish pond resources through the introduction of floating gardens may increase production per unit area and provide additional income to farmers on a sustainable basis. However, only few studies have been reported on legume-vegetables intercropping in a floating garden hence, this study was conducted.

METHODOLOGY

Experimental Design and Treatments

This study was conducted in a fishpond located at Poblacion, Valencia, Bukidnon, Philippines from December to March 2016.The experiment was laid out in a Randomized Complete Block Design (RCBD), with seven treatments replicated three times. Each treatment was assigned randomly in each plot. The following were the treatments:T_1 – Mungbean (monocrop); T_2 – Pechay (monocrop);T_3 – Upland kangkong (monocrop); T_4 – Lettuce (Control); T_5 – Mungbean + Lettuce; T_6 – Mungbean + Upland Kangkong; T_7 – Mungbean + Pechay.

Cultural and Management Practices

1. Floating Garden Establishment

The floating garden (Fig. 1) that was used in the study measures 1m x 0.7 m with 20cm depth. It was filled up with soil media at 1:1 ratio of garden soil and vermicast. The boxes were supported by bamboo poles with plastic bottles to prevent from sinking.

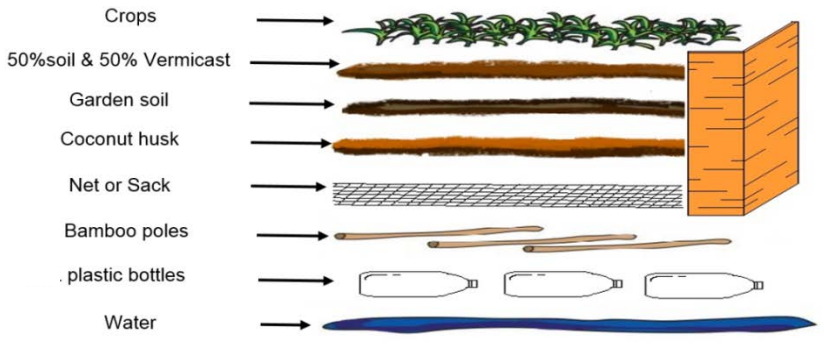


Figure 1. Floating garden set-up

2. Planting of Mungbean Seeds

Healthy seeds that are free from impurities, insect damage and diseases were selected. The mungbean seeds were planted at a distance of 10 cm x 50 cm. The seeds were sown at 1 inch deep and covered with fine soil.

3. Preparation of Vegetable Seedlings.

Sowing of Seeds - Seeds were sown thinly in shallow furrows of the soil and water with utmost care to prevent exposure and displacement.

Thinning-This was done seven days after emergence to remove unwanted seedlings and to maintain equal plant population per plot.

Weed Management-Weed competition was minimized through hand weeding. Hand weeding was done two weeks after seed germination and every two weeks thereafter.

Pest Management- Insect pests and diseases were controlled using the Integrated Pest Management (IPM) strategies to minimize pest damage.

Harvesting and Post-Harvest Operations

A. Mungbean

Priming - Priming was done at three days interval when the mungbean pods turned brown or black until all pods were harvested.

Shelling - Pods were shelled manually and were placed in a properly labeled paper bags.

Drying - Grains were sundried until the moisture content reached approximately 14%.

Cleaning - Grains were cleaned after drying to remove inert matters.

B. Vegetables

The vegetables (lettuce, upland kangkong and pechay) were harvested at 30 days after sowing. This was done early in the morning to minimize mechanical injury. The harvested vegetables were properly cleaned from any soil debris and the unmarketable leaves were also removed.

Data Gathered

A. Agronomic and Yield Characteristics of Mungbean

1. Number of days to flower – This was determined by counting the number of days from planting until 50% of plants have flowered.
2. Number of days to maturity – This was obtained by counting the number of days from planting until 80% of the pods turned brown or black.
3. Plant height (cm) – This was done by measuring the five randomly selected plants in each treatment plot during vegetative and maturity stage. This was measured from the base of the plant up to its apex using a meter stick.
4. Pod length (cm) – This was obtained by measuring the length of 5 randomly selected pods using a ruler.
5. Pods plant^{-1} – These was obtained by counting the number of pods of 5 randomly selected plants.
6. Weight of 100 seeds (g) – This was determined by weighing 100 randomly selected seeds per plot using a digital balance.
7. Grain yield – This was done by weighing all the seeds obtained from effective harvest area (0.70 m²) in each plot. Yield per hectare was computed using the formula:

$$\text{Grain yield (kg/ha)} = \text{plot yield} \times \frac{10{,}000\ \text{m2}}{\text{EHA}} + \frac{100 - \text{MC}}{86}$$

B. Characteristics of Vegetables

1. Plant height (cm) – This was measured from the base to the tip of the 5 kangkong plants and measured using a ruler and the average was determined.
2. Weight (g) per plant – The average weight was determined from 5 plant samples.
3. Herbage Yield – This was done by weighing all the leaf obtained in effective harvest area ($0.70m^{2)}$ in each plot. Yield per hectare were computed using the formula:

$$\text{Herbage yield (kg/ha)} = \text{plot yield} \times \frac{10{,}000\ m^2}{0.70\ m^2}$$

Statistical Analysis

The data gathered were analysed statistically using the analysis of variance in Randomized Complete Block Design (RCBD) and treatment means were compared using the Duncan's Multiple Range Test (DMRT).

Return on Investment

The economic analysis was determined by computing the return on investment (ROI). The ROI per hectare of mungbean and vegetable production was estimated based on the prevailing selling price. This was computed using the formula:

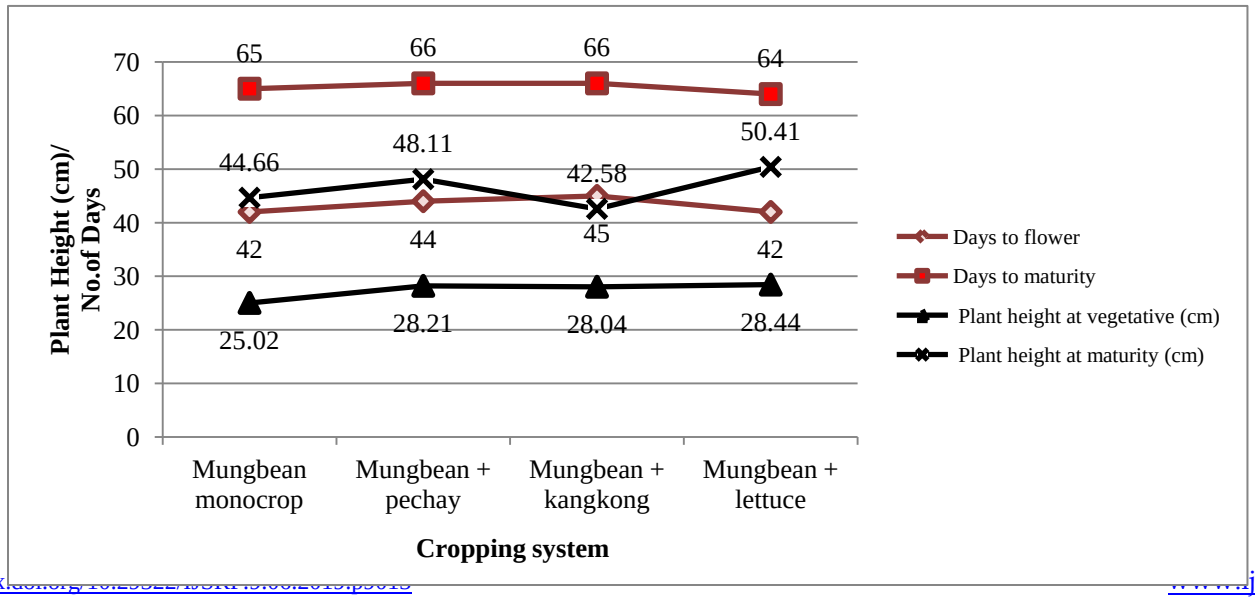
$$\text{Return on Investment} = \frac{\text{Net Income}}{\text{Cost of Production}}$$

RESULTS AND DISCUSSION

Agronomic Characteristics of Mungbean

Plant Height, Days to flower and maturity

There was no significant difference on the plant height of mungbean at vegetative and maturity stage (Fig. 2). The plant height ranged from 25.02 cm – 28.44 cm at vegetative and 42.58 cm-50.41 cm at maturity stage. Generally, mungbean intercropped with vegetables were taller than the sole crop. The intercropping system also had no influence on the days to flower and days to harvest of mungbean (Fig. 1). All mungbean plants flowered and matured simultaneously regardless of the cropping system employed.



Figue 2. Plant Height (cm), number days to flower and days to maturity of mungbean intercropped with vegetables in a floating garden.

Yield and Yield Components of Mungbean

Pod Length and Weight of 100 Seeds

The pod length and weight of 100 seeds showed no significant differences among treatments as presented in Table 1. The pod length ranged from 7.43 cm to 7.87 cm while the weight of 100 seeds ranged from 5.73 g to 6.90 g. Mungbean intercropped with upland kangkong obtained the lowest mean value in both parameters.

Pods Plant^{-1}

The number of pods plant^{-1} is an important parameter of mungbean because it is directly correlated with the bean yield. The higher the number of pods per plant, the higher is the yield. The different intercropping treatments caused significant variation in the number of pods plant-^{1} of mungbean. Pods plant^{-1} was higher in case of sole mungbean as compared to those intercropped with vegetables (Table 1). However, it was observed that among the intercropping system, mungbean+pechay had the most number of pods and lowest in mungbean+kangkong. Possible reason for higher number of pods plant^{-1} in sole mungbean plots might be attributed to the absence of inter-specific competition and better utilization of nitrogen from the organic fertilizer and fixed by root nodule. Similar result was reported by Khan *et al*. (2012) who observed that number of pods plant^{-1} of mungbean were higher in monoculture as compared to their corresponding intercrop.

Grain Yield (kg/ha)

Intercropped mungbean had lower yield as compared to sole mungbean cultivation as shown in Table 1. Grain yield was highest in sole mungbean with 509.33 kg. Among the intercrop combinations, mungbean + lettuce obtained the highest yield (338.10 kg) and lowest in mungbean + kangkong intercropping (129 kg). The increase in the yield of mungbean in sole cropping is attributed to the favorable growing conditions which improved its nutrient and water uptake when in a floating garden. It might be due to increased nitrogen fixation and full utilization of nutrients during the growing period of sole mungbean while in the case of intercropping, these resources were shared by vegetables which are strong competitors of mungbean (Thavaprakaash *et al*., 2005). The result conforms to the study of Saleem (2010) who reported that mungbean grain weight and yield were convincingly higher when it was sown alone as compared to intercropped mungbean. Khan, *et al.* (2012) also reported that sole cultivation of mungbean was the most effective intercropping system in terms of yield and yield components. The pond sediments may also add up to the nutrient requirement of mungbean and vegetables that may improve their yield characteristics. It is rich in nitrogen, exchangeable potassium, phosphorus and organic matter, hence it has a high potential as nitrogen and potassium fertilizer and as a soil conditioner (Boyd *et. al*., 2002; Muendo *et. al*., 2014).

Table 1. Yield characteristics of mungbean intercropped with vegetables in a floating garden

TREATMENTS	POD LENGTH (cm)	PODS PLANT^{-1}	WEIGHT (g) of 100 SEEDS	GRAIN YIELD (kg/ha)
Mungbean (monocrop)	7.64	10.20^{a}	6.90	509.33^{a}
Mungbean + (pechay)	7.59	8.20^{b}	6.67	163.33^{c}
Mungbean + (kangkong)	7.43	5.13^{c}	5.73	129.00^{c}

Mungbean + (lettuce)	7.87	5.23[c]	5.83	338.10[b]
F-test	ns	**	ns	**
cv (%)	7.89	1.88	10.42	7.48

Means in a column followed by the same letter are not significantly different at 5% DMRT

Characteristics and Yield of Vegetables

Plant Height

The different cropping systems did not influence the plant height of vegetables planted as monocrop and as intercrop (Table 2). However, plants were taller in sole cropping of pechay and lettuce. In intercropping combination, plants were shorter due to shading effect of mungbean on leafy vegetables which resulted in lesser light interception.

Weight Plant^{-1}

Statistical analysis revealed no significant difference on the weight (g) of pechay as presented in Table 2. Sole pechay had comparable weight to intercropped pechay. Lettuce planted as monocrop obtained heavier weight with a mean value of 26.03 grams which varied significantly when intercropped with mungbean with a mean of 23.13 grams. Lettuce planted as monocrop had full utilization on the nutrients present in the soil therefore resulting in the increase in weight. The decrease in weight of intercropped can be attributed to the interspecific competition of the mungbean and vegetables in terms of light, space, nutrient, and other necessary elements needed for plant growth and development. Meanwhile a significant difference was observed in the weight of upland kangkong. Intercropped kangkong had heavier weight with 51.53 g as compared to sole crop with 33.13 g. This indicates that both crops are compatible and complentary in an intercropping scheme. Plants species with different root and uptake patterns like in the case of mungbean and kangkong can efficiently utilize the available nutrients and even increase the nitrogen uptake (Matusso *et al*., 2012 and Undie *et al*., 2012) In addition, intercrops are very productive when the component crop varies greatly in growth duration so that their maximum condition for growth resources occurs at different periods (Ijoyah, 2012).

Table 2. Characteristics of leafy vegetables intercropped with mungbean in a floating garden

TREATMENTS	PLANT HEIGHT OF VEGETABLES (cm)	WEIGHT PLANT^{-1} (g)	HERBAGE YIELD (kg/ha)
Pechay (monocrop)	27.23	71.80	3973.33
Pechay (intercrop)	25.20	62.45	1819
F-test	ns	ns	**
CV (%)	7.04	27.02	12.7
Kangkong (control)	49.6	33.13	4673.33
Kangkong (intercrop)	50.17	51.53	2652.37
F-test	ns	*	*
CV (%)	2.13	2.13	7.05
Lettuce (control)	26.03	26.03	997.78
Lettuce (intercrop)	23.13	23.13	664.95

F-test	ns	*	**
cv (%)	22.69	8.52	3.55

ns- means not significantly different at 5% DMRT

Herbage Yield

Statistical analysis revealed highly significant differences on the herbage yield of all vegetables (Table 2). Higher yield was attained in sole cropping as compared when intercropped with mungbean. The yield reduction in intercropped vegetables is attributed to the competition between crops in terms of growth factors. Light competition might be the primary limiting factor as the other major growth factors such as water and nutrients were at adequate levels throughout the cropping system. According to Thayamini & Brintha (2010), high intercrop productivity is attained if early maturing component like vegetable is grown with little interference from the late growing crop. Thus, the choice of accurate cultivars and agronomic manipulations to certify the most effective use of limiting resources is the key part for high crop yield.

Return on Investment

An analysis on cost and return of intercropping mungbean with different leafy vegetables is presented in Table 3. Higher gross income was obtained from all intercrop combinations than sole crop mungbean. Among the intercropping combinations, mungbean + upland kangkong intercropping system obtained the highest gross income (115, 415), net income (54, 478) and ROI (0.89) and lowest in mungbean+pechay intercropping. The results of increased productivity and monetary returns were consistent with the earlier reports of yield advantage of crop mixture as compared to monoculture (Islam et al., 2014; Ahmed *et al.*, 2013).

Table 3. Cost and return analysis of mungbean + leafy vegetable intercropping in a floating garden

TREATMENTS	Yield (kg/ha)		GROSS INCOME	TOTAL COST OF PRODUCTION	NET INCOME	ROI
	GRAIN	HERBAGE				
Mungbean	509.33		40, 746	59, 510	18, 764	0.31
Pechay		3973	139,067	57, 550	81, 517	1.42
Kangkong		1819	186, 933	57, 790	129, 143	2.23
Lettuce		997	119, 733	57, 615	62, 118	1.08
Mungbean + Pechay	163	1819	76, 671	60, 937	15, 734	0.26
Mungbean + Kangkong	129	2652	115, 415	60, 937	54, 478	0.89
Mungbean + Lettuce	338	665	107	60, 937	45, 905	0.75

Prevailing prices of mungbean and vegetables at Valencia City, Bukidnon, Philippines

Mungbean = Php. 80.00 kg
Pechay = Php. 45.00 kg
Upland kangkong = Php. 40.00 kg
Lettuce = Php. 145.00 kg

CONCLUSION

Among the treatments, mungbean + upland kangkong intercropping system was the most productive and profitable than other cropping combinations as it had the highest gross income, net income and ROI. Though productivity of mungbean was reduced with intercropping, the loss in yield was compensated by the herbage yield of vegetables.

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