Intercropping of Rice (*Oryza sativa)* Varieties AT 401 and AT 402 with Green Gram (*Vigna radiata)* and Radish (*Raphanus sativus)* in *in vitro* Condition

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Abstract
A major problem encountered in tropical agriculture is the reduced soil fertility due to monoculture. Therefore, there is a need to improve productivity of soil by using environmental friendly methods. Rice (*Oryza sativa* L.) is the major staple food in the tropics and green gram (*Vigna radiata* L. variety; MI 5) is a major legume which is intercropping with rice. Radish (*Raphanus sativus* L.) is a popular vegetable with edible root and leaves. Present study was focused on investigating the effect of green gram and radish, on vegetative growth of improved rice varieties AT 401 and AT 402 under *in vitro* conditions. Seeds of two rice varieties, green gram and radish were cultured in Murashige and Skoog basal Medium (MS). Treatments were; AT 401 with green gram, AT 401 with Radish, AT 402 with green gram, AT 401 with radish, green gram with radish, sole AT 401, sole AT 402, sole green gram and sole radish. Completely Randomized Design (CRD) with three replicates was used. Statistical analysis was carried out using the Student Newman-Kuells Means Separation. Height, weight of each plant and number of tillers in rice varieties were recorded 30 days after planting. Vegetative growth of rice varieties AT 401 and AT 402 were significantly enhanced by intercropping with radish when comparing to the sole AT 401 and sole AT 402 showing, mean plant weight (0.3g, 0.31g) and number of tillers (5, 7) respectively. It was reduced with green gram under *in vitro* conditions displaying mean plant weight (0.2g, 0.08g) and number of tillers (1, 1), respectively.

Key words: *Oryza sativa* varieties AT 401, AT 402, Vigna radiata, *Raphanus sativus,* Intercropping, *In vitro*

Introduction

Rice (*Oryza sativa L.*) is a major staple food crop in the tropics (Ogutu *et al.,* 2012). It is the most important crop occupying 34% (0.77 /million ha) of the total cultivated area in Sri Lanka. Sri Lanka currently produces 2.7 million tons of rough rice annually and satisfies around 95% of the domestic requirement (Department of Agriculture, 2006). There are several improved cultivated rice varieties in Sri Lanka. Among them AT 401 and AT 402 are two improved cultivated rice verities issued by Department of Agriculture, Ambalantota. The variety AT 401 is recommended for coastal saline area while AT 402 recommended for dry and intermediate zones with assured supply of water (Department of Agriculture, 2006). Radish (*Raphanus sativus* L., 2n=18) is a common vegetable in Asia and also most parts of the world. This plant produces edible root with different shapes. Apart from culinary purposes, radish has diverse medicinal properties as well (Mohomad *et al.,* 2009). In Sri Lanka, Radish is one of the vegetables that can be grown in all agro ecological regions throughout the year if adequate moisture is available. Two varieties, Japan ball Rabu and Beeralu Rabu are recommended for upcountry and low country, respectively (Department of Agriculture, 2006). Crop diversification through intercropping has long been recognized as a kind of biological insurance against risks and abnormal rainfall behavior in dry environment. It increases the cropping intensity, productivity, profitability, optimized utilization of soil, water, nutrients and sunlight. Besides increased overall productivity and income, intercropping of legumes with cereals helps in conserving moisture by reducing runoff, improving physical properties of soil and building-up of soil fertility. Legumes like green gram/black gram being short duration herbs may constitute potential intercrop in rice under rain fed conditions (Lawrence and Gohain, 2011). Legumes

such as green gram (*Vigna radiata* L), cowpea *etc.* and non-legumes such as vegetables are intercropped with rice; however, there are no reports for rice inter cropped with radish in Sri Lanka. *In vitro* study is needed before establishing field experiment regarding those facts to get an idea about those relationships. Therefore, the current study was undertaken to *in vitro* investigate the effect of green gram and radish on the growth of improved cultivated rice varieties AT 401 and AT 402.

Materials and Methods

Plant source

Seeds of rice (AT 401, AT 402), green gram and radish (Beeralu) were purchased from the Seed and Planting Material Division, Department of Agriculture, Sri Lanka.

Preparation of culture media

Murashige and Skoog Medium (MS medium) without hormones was used to prepare aseptic cultures. Prior to the addition of agar, the pH of the medium was adjusted to 5.8-6.0 with 1N NaOH or 1N HCl solution and autoclaved for 20 min at 121°C and 1.06 kg cm^{-2}.,

Establishment of aseptic cultures

Seeds were surface-sterilized by washing tap water, soapy water, immersing in 70% ethanol for 3 minutes, three times from distilled water and soaking in a 20% Clorox for 20 minutes, respectively. Sterilized seeds were then rinsed three times in sterilized distilled water and inoculated on a medium. The seeds were cultured under light for 10 days (Dahanayake *et al.*, 2010).

Each treatment and controls had three replicates with 4 plants/bottle and 2 plant varieties/bottle.

Treatments no	Treatments
1	AT 401 + Green gram
2	AT 401 + Radish
3	AT 402 + Green gram
4	AT 402 + Radish
5	Radish + Green gram

Treatments no	Controls
6	AT 401 + AT 401
7	AT 402 + AT 402
8	Green gram + Green gram
9	Radish + Radish

Data collection and analysis

Experiment was arranged according to the Completely Randomized Design (CRD). Aseptic seedlings were evaluated 30 days after initiation. Height and weight of seedlings in different treatments were recorded. Statistical analysis was carried out using the Student Newman-Kuells Means Separation Test of SAS program (9.1.3).

Results and Discussion

The data in the Table 1 indicated mean plant height (8.46cm), mean plant weight (0.30g) and mean number of tillers (5) were significantly different in AT 401 with radish comparing to others. Lowest mean height (4.61cm) was observed from the cultures which were containing AT 401 with green gram and lowest mean weight (0.09 g) was observed from cultures which were containing AT 401 only.

Furthermore the data (Table 1) revealed that mean plant heights of rice cultivar AT 402 were not significantly different with green gram as well as radish. However mean weights and numbers of tillers were significantly different from AT 402 mono cultures and cultures with radish. Mean plant weight (0.31g) and number of tillers (7) in AT 402 which were with radish was highly significantly different from AT 402 sole cultures and cultures with green gram. Mean plant heights of AT 402 in sole AT 402, AT 402 with green gram and AT 402 with radish were not significantly different.

Mean plant heights of green gram (GG) were not significantly different in each treatment (sole GG, AT 401+GG, AT 402+GG). However maximum mean plant weight of green gram (0.75 g) was observed from green gram with AT 402.

Highest mean plant height of radish was observed from radish with both rice varieties (AT 401 and AT 402) 15.83cm and 16.33cm, respectively. The plant heights which obtained from sole radish and radish with green gram were lower than it.

The mean height and mean weight of green gram and radish were not significantly different from sole green gram and sole radish cultures. Therefore, the growth of radish was not affected by green gram and the growth of green gram was not affected by radish in *in vitro* conditions. However, results may be different under field conditions. Therefore, it can be investigated under field conditions to confirm the results obtained under laboratory conditions. There were no reports available about green gram intercropping with radish and rice intercropping with radish in field level. Therefore, those *in vitro* results (highest number of tillers) open a pioneer avenue to investigate rice and radish intercropping in *in vivo* conditions. Since number of tillers in AT 401 and AT 402 were remarkably high when cultured with radish. Glucosinolates is the major chemical which contain in radish (Paul *et al.*, 2006) and it may have caused this significant difference of vegetative growth in rice cultivars and it is to be confirmed with further studies. In rice, high number of tillers means more panicles for plant and consequently the final yield is increased. Mean plant height and mean plant weight of radish were highest when cultured with rice varieties. That results revealed growth of radish was increased due to rice cultivars. Radish can be grown in all agro ecological regions throughout the

Table 1. Effect of rice + green gram, rice +radish intercropping on vegetative growth of rice (AT 401, AT 402) and radish + green gram intercropping on vegetative growth of radish and green gram.

	Treatments	Height (cm)	Weight (g)	No of Tillers
Effects on AT 401	AT 401	6.45^{b}	0.09^{c}	1^{b}
	AT 401+GG	4.61^{c}	0.20^{b}	1^{b}
	AT 401+Radish	8.46^{a}	0.30^{a}	5^{a}
Effects on AT 402	AT 402	12.21^{a}	0.12^{b}	1^{b}
	AT 402+GG	10.63^{a}	0.08^{b}	1^{b}
	AT 402+Radish	8.82^{a}	0.31^{a}	7^{a}
Effect on Green Gram (GG)	GG	21.78^{a}	0.11^{b}	-
	AT 401+GG	21.62^{a}	0.20^{b}	-
	AT 402+GG	19.17^{a}	0.75^{a}	-
	Radish+GG	22.88^{a}	0.08^{b}	-
Effect on Radish	Radish	14.33^{b}	0.25^{a}	-
	AT 401+Radish	15.83^{a}	0.26^{a}	-
	AT 402+Radish	16.33^{a}	0.26^{a}	-
	Radish+GG	14.50^{b}	0.25^{a}	

Means fallowed by the same lower case letters in each column are not significantly different at 5% level in Duncan's Multiple Range Test.

year if adequate moisture is available in Sri Lanka. Beeralu rabu the variety which were used for present study is recommended for low country in Sri Lanka. (Radish: *Raphanus sativus* L) and AT 401 is recommended for coastal saline area while AT 402 recommended for dry and intermediate zones with assured supply of water (Department of Agriculture, 2006). AT 401 and AT 402 belongs four to four and a half month age rice group (Rice, 2006). Thus there is a possibility to intercrop radish with these two selected rice varieties. Intercropping of rice and, radish may be an effective method to enhance both rice and radish yields and this can be tested under in vivo conditions.

As reported by Lawrence and Gohain (2011), plant heights of rice differ significantly due to intercropping with green gram under *in vivo* conditions. Same results were observed in the present study with highest plant height was recorded in sole rice plots and lowest was recorded when rice was planted with green gram.

Furthermore Ogutu *et al.* (2012) and Jabbar *et al.* (2010) stated that the intercropping rainfed rice with legumes significantly reduced the grain of rice yield. Cowpea (*Vigna unguiculata*) caused significant yield reduction in grain rice of associated rice crop when compared to sole crop. The significant yield reduction was also observed in rice and common bean intercrop (Ogutu *et al.*, 2012). Most of legumes have reduced rice yields compared to sole rice cultivation. Similar results were observed in the present study for rice varieties AT 401 and AT 402.

The growth of rice varieties (AT 401 and AT 402) were enhanced due to intercropping with radish and were reduced by green gram under in vitro conditions. Growth of green gram with radish has not affected the growth of each crop.

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