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Determine the Effective Spatial Arrangement in Intercropping Pechay (*Brassica rapa*, L. cv group Pak Choi) and Spring Onions (*Allium fistulosum*)

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ABSTRACT

Intercropping, an essential cultivation pattern in modern agricultural systems, increases crop yields and soil quality. Pechay and spring onions are frequently intercropped to increase productivity per unit area. However, its management practice follows simple natural principles and its practice is limited only by the imagination of farmers. The objective of the study was to determine effective spatial arrangements for intercropping. The treatments tested were three intercropping ratios of peachy and spring onion in 1:1, 1:2, and 2:1 arrangements compared against the sole cropping. Land equivalent ratio (LER) was used to compare the land use efficiency of the intercrops with each sole crop and IBM SPSS software's were used to compute the analysis of variance. The total yield of intercropped crops were greater than sole cropping, shown by $LER > 1$. The overall advantage of intercropping ranged from 47% to 66%. The highest land equivalent value was recorded for 2:1 *pechay* and spring onion row arrangements indicated a yield advantage of 66% over sole crop. The partial land equivalent value of both crops in intercropping was less than one indicating the cohesiveness of both crops in intercropping. Thus, it can be concluded that 2 *pechay*: 1 spring onion intercropping is a viable agronomic option in increasing land use efficiency and increased food security. It is, therefore, imperative to demonstrate the best treatment under farmer's condition.

INTRODUCTION

Food shortage is one of the most significant issues facing the globe today due to the rapidly expanding population and constrained agricultural land, highlighting the urgent need for more in-depth research to find solutions (Bantie, 2015). The ability to increase yield by a variety of means and cultivation innovative techniques, including but not limited to the use of genetically modified and disease-resistant plants, finding new cultivars with a good quantity and quality, or the use and implementation of cutting edge technologies, as well as making the most of already available resources in countries, has been expressed in numerous studies conducted around the world (Tsubo *et al.*, 2004).

The Department of Agriculture (DA) is the government agency responsible for all agricultural activities in the Philippines. The DA has adopted crop diversification as a strategy to promote and hasten agricultural development. One of which is the intercropping of plants with the main crop and a cash crop. This strategy helps attain the goal of the Department in increasing productivity and farm income (2019). Agriculture Secretary Manny F. Piñol urged the farmers to practice intercropping and venture in the value-adding and processing of different plants such as coconut to generate extra income during his visit in Barangay Panikihan, Gumaca, Quezon on May 7, 2019.

Intercropping is strategy that involves cultivating two or more crops in the overlapping or side-by-side in the same field, it is recommended as a potentially environmentally sound cropping system that may solve the dilemma of greater production from 'less' or equivalent land. It aims

to capture the complementary and helpful interactions between species to enhance capture and potency within the use of resources, and yield and profit per unit land (Z. Wang *et al.*, 2014).

According to Center 2021 "Which vegetables grows together?" brassicaceae family like *pechay* and amaryllidaceae family like spring onions are some of the vegetables grows well when they are intercrop. Spring onions will generally work best with Brassicaceae family like *pechay*, hence, it is great at repelling insect pests like worms, loopers, and maggots. All Brassica vegetables that fare well when planted next to onions, as the onions keep away most of the pests that plague crops.

Pechay and spring onions are frequently intercropped in the Philippines to increase productivity per square meter. However, its management strategy adheres to straightforward natural laws, and its application is only constrained by farmers' creativity (one row of *pechay* planted with one row of spring onions). There are no published research to increase the productivity of this type of planting system. The yields of the component crops therefore vary greatly amongst farms. Therefore, the goal of this study was to identify the optimal spatial arrangement for intercropping *pechay* and spring onions.

MATERIALS AND METHODS

Study Area

The study was carried out in Salvacion, Bayugan City for the period of October to December in which annual temperatures range between 22 and 30°C. With geographic coordinates 8° 41' North, 125° 43' East in an altitude between 200 m and 270 m (Google Earth, n.d.).

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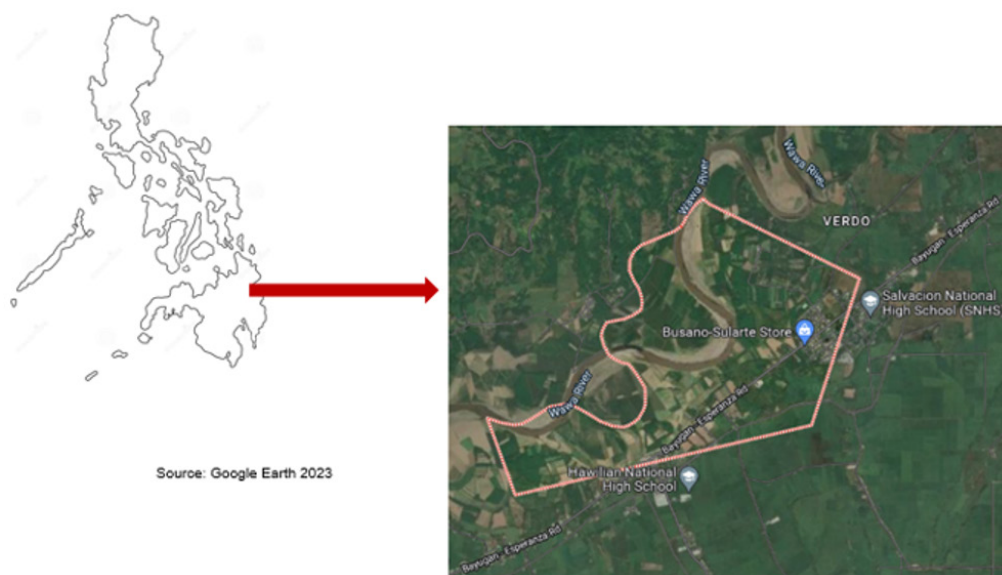


Figure 1: The Study Site – P-18 Salvacion, Bayugan City

Soil of experimental site was sandy loam in texture, and cultivation of the land for preparation of planting.

Experimental design and treatments

The field experiment was laid out in a randomized complete block design with three repeats. The gross plot area was $0.5 \text{ m} \times 2 \text{ m}$ (2 m^2). The distance between each plots and replications was 0.5 m . The treatments consisted three intercropping combinations viz: two rows of *pechay* + one row of spring onion, one row of *pechay* + one row of spring onion, one row of *pechay* + two rows spring onions, *pechay* only and spring onion only. The *pechay* variety used was Brassica rapa, L. cv group Pak Choi and White lisbom (AGM) for spring onion (*Allium fistulosum*). Both *pechay* and spring onion were sown at the same time in rows 20 cm apart with 10 cm intra-row spacing based on the required treatment. Pechay seeds were sown at the rate of two seeds per hill. Both crops were applied with inorganic complete fertilizer (14-14-14). All other the agronomic practices were conducted as per the recommendation given by department of agriculture and rural development.

Data Collection and Measurements

Data on plant height, length of leave, and number of leaf of both *pechay* and spring onion were determined from 10 randomly sampled plants per plot during physiological maturity. The yield and yield component of the plants/crop in the intercrop was determined from the harvestable plot in kg/m^2 .

Data Analysis

Data was subjected to analysis of variance (ANOVA) following statistical procedures of IBM SPSS software. The level of significance was set at ($p \leq 0.05$). Whenever treatment effects were significant, the means were separated using Duncan's multiple range tests.

The land use efficiency was calculated. The land equivalent ratio is considered a measure of the efficiency of grain or

economic yield of the crop in mixture, compared with sole crops, and based on land use. LER indicates the efficiency of intercropping for using the resources of the environment compared with mono-cropping (Mead and Willey 1980). The LER was calculated as follows: (Willy and Osiru 1972).

Land equivalent ratio (LER) = $(YAB/YAA) + (YBA/YBB)$
Where: YAB= yield of crop A (*pechay*) when intercropped with crop B (spring onion), YBA=Yield of crop B (spring onion) when intercropped with crop A (*pechay*), YAA=Yield from sole planted crop A (*pechay*), YBB=Yield from sole planted crop B (spring onion).

A LER of 1.0 would indicate that the amount of land required for both crops in the different pattern was the same as that for each crop grown individually. It is also an indicator of complementarity of the component crops. This would imply that there was no advantage of intercropping over pure crops. An LER greater than 1.0 would show a yield advantage of intercropping over pure crops. In contrast, when LER is lower than one the intercropping negatively affects the growth and yield of the plants grown in mixtures (X. Wang & Gao, 2019).

RESULTS AND DISCUSSION

Pechay Component

The plant height, height of leaf, numbers of leaf and vegetable yield under the different treatments are shown in Table 1. The only element that is not significantly impacted by the various treatments is the number of leaves, although plant height, leaf height, and food production were significantly ($P < 0.05$) influenced by the treatments. The sole cropping method produced the tallest plants, 29% taller than those grown in intercropping ratios of one row of *pechay* and two rows of spring onions. (Table 1). The increase in plant height under sole cropping might be attributed to the absence of other species competition for growth resources.

The yield of *pechay* was also significantly ($P < 0.05$)

influenced by the effect of treatments; consequently, it was highest under sole cropping (0.071 kg.m²), followed by two rows of *pechay* and one row of spring onion (0.064 kg.m²), which increased by 30% and 10%, respectively, in comparison to the intercropping treatment, which consists of one row of *pechay* and two rows of spring onion (0.045 kg.m²). The largest plant population and less inter-plant competition may be responsible for the yield improvement under solitary cropping compared to intercropping treatments.

The combined mean data presented in Table 1 showed significant yield advantage for two rows of *pechay* and one row of spring onion planting arrangement compared to the other intercropping treatments according to the productivity of *pechay* plants, which reached 0.064 kg/m², compared to 0.045 kg/m² in one row of *pechay* and two rows of spring onion planting pattern which might be attributed to the decreased inter and intra competition between *pechay* and spring onion. The increased yield for

this treatment resulted in the low density of spring onion plants per unit area which allows *pechay* plants to get a greater domain, for large biological activity compared with *pechay* in the two spring onion and one *pechay* arrangement, where there was a high density of spring onion plants.

The partial land equivalent ratio of *pechay* in the intercropping system were significantly ($P<0.05$) influenced by *pechay* and spring onion intercropping arrangements (Table 1). The highest PLER of 0.90 was recorded for two rows of *pechay* and one row of spring onion compared to the one row of *pechay* and two rows of spring onion planting pattern (PLER = 0.63). The results revealed that an increase in *pechay* planting ratio also increase partial land use efficiency of *pechay* in either of the intercropping patterns. Those results agree with Kidane *et al.* (2017) and Saddam Aref Al-Dalain (2009) and Yayeh (2015).

Table 1: Yield and yield component of *pechay* with different planting patterns

Planting Patterns	Pl.ht (cm)	Height of leaf	Number of leaves	Yield (kg/m ²)	PLER
2 rows of <i>pechay</i> +one row of spring onion	34.3b	18.4a	8.3a	0.064a	0.90c
One row of <i>pechay</i> +one row of spring onion	25.4a	15a	6.9a	0.054a	0.76b
One row of <i>pechay</i> +two rows of spring onion	24.8a	15a	7.5a	0.045a	0.63a
<i>Pechay</i> only	35.1a	21a	8.9a	0.071a	1d
CV%	16.1	14.5	9.6	16.9	17.2

Values followed by the same letter in a column are statistically similar at 0.05% level according to Duncan's multiple range tests, pl.ht= plant height, PLER= partial land equivalent ratio

Spring Onion Component

Plant height, height of leaf, number of leaf and plant yield under the different treatments is shown in Table 2. Plant height was significantly ($P<0.05$) influenced by the planting ratio. The greatest plant height was spring onion only which resulted in an increase of 25% over one *pechay* and one spring onion row arrangement which resulted in the shortest plant height (26.88 cm). Intercropping *pechay*-spring onion in different spatial arrangement significantly affect yield of spring onion ($P<0.05$). There was a significant increase in productivity of sole spring onion (0.045 kg/m²) compared with the intercropped treatments which ranged from 0.034 to 0.038 kg/m². The lowest spring onion mean yield was obtained at two rows *pechay* and one row spring onion (0.034 kg/m²). The reduction ratio of spring onion productivity in two rows *pechay* and one row spring onion arrangement was 24% compared to the sole cropped spring onion arrangement due to low plant population per unit area.

The combined mean data presented in Table 2 shows that there is an advantage to one row *pechay* and two rows spring onion over other intercropping treatments according to the productivity of spring onion plants, which reached 0.038 kg/m², compared with 0.034 kg/m² in two rows *pechay* and one row spring onion. This significant increase in spring onion yield was attributed

to the decreased inter and intra competition between *pechay* and spring onion; and spring onion plants, which resulted from low density of *pechay* plants per unit area that allowed spring onion plants to get a greater domain, which is needed for large biological activity compared with spring onion under two rows *pechay* and one row spring onion intercropping arrangements, where there was a high plant density of *pechay* plant. The results are in agreement with Ebwongu *et al.* (2001) who reported that productivity of a crop decreased when intercropped compared to the plantation of sole plant only, while it increased by increasing plant density during intercropping treatments.

The partial land equivalent ratio of spring onion in intercropping systems were significantly ($P<0.05$) influenced by *pechay* and spring onion intercropping arrangements (Table 2). The highest PLER (0.84) was resulted from one row of *pechay* and two rows of spring onions compared with 0.76 for the two row *pechay* and one row spring onion planting pattern. The results revealed that increase in spring onion planting ratio increased partial land use efficiency of spring onion in either of the intercropping patterns. As mentioned earlier that productivity of a crop increased by increasing plant density during intercropping treatments, the trend implies that an increase in the number of rows of spring onion

Table 2: Yield and yield component of spring onion with different planting patterns

Planting Patterns	Pl.ht (cm)	Length of leaf	Number of leaves	Yield (kg/m ²)	PLER
2 rows of <i>pechay</i> +one row of spring onion	27a	20.25a	10.63a	0.034a	0.76a
One row of <i>pechay</i> +one row of spring onion	26.88a	20.38a	12.5a	0.035a	0.78b
One row of <i>pechay</i> +two rows of spring onion	27.88a	21.25a	12.75a	0.038a	0.84c
Spring onion only	33.75a	24.63a	11a	0.045a	1d
CV%	9.8	8.2	7.8	11.3	11.1

Values followed by the same letter in a column are statistically similar at 0.05% level according to Duncan's multiple range tests, *pl.ht*= plant height, PLER= partial land equivalent ratio

increased plant yield showing flexibility for variation in potentiality for intensification of cropping. Similar findings were reported by Yilmaz *et al.* (2001), Sharaiha *et.al.* (2004), Tesfay *et al.* 2006 and Yayeh (2015).

Combined Yield

The combined yield of *pechay* and spring onion in intercropping systems were significantly ($P<0.05$) influenced by the intercropping arrangements (Table 3). The highest combined mean yield of the component crops (0.098 kg/m²) was obtained from two *pechay* and one spring onion rows followed by one *pechay* and one spring onion row planting pattern with a yield of 0.089 kg/m² (Table 3). The highest yield in the intercropping treatment could be attributed to growing spaces being varied; temporal growth variance between two varying crops; a combined increase in making better use of light, soil moisture content and nutrients as discussed by Jamshidi *et al.* (2007). The highest yield in intercropping as opposed to sole cropping was supported by several studies (Amin *et.al* (1997), Sharaiha *et.al.* (2004), Tesfay *et al.* (2006), Temesgen and Wondimu (2012) and Yayeh (2015). Partial LERs for *pechay* and spring onion grown in the intercropping systems are less than unity (Table 3) indicating that both plants are compatible for intercropping under different cropping intensities. The highest PLER for spring onion (0.84) was recorded for one row of *pechay* and two rows of spring compared with (0.76) in the two *pechay* and one spring onion planting pattern. Likewise, the highest PLER for *pechay* (0.90) was recorded from two rows of *pechay* and one row of spring onion compared with (0.63) in one row *pechay* and two

rows spring onion planting pattern. Partial equivalence of either crop increased as equivalence of the other component decreased.

Land Equivalent Ratio (LER)

Mass yield is a helpful phrase in assessments of the crop productivity of solitary cropping systems (mass per unit area). Direct comparison is challenging in intercropping systems, though, as different plant species growing on the same plot of land produce distinct outputs (Willey 1984). In this case, crop productivity should be evaluated using a common unit. A widely used method is the land equivalent ratio (LER) (Willey 1984). Total LER were significantly ($P<0.05$) influenced by intercropping arrangements (Table 3), which shows an advantage over pure stands in terms of the use of environmental resources for plant growth as reported by Mead and Willey (1980). In this study, TLER ranged from 1.47 to 1.66. The combined yield advantage in terms of total LER indices was greatest in the cases of two rows *pechay* and one row spring onion intercropping arrangement (1.66) which might be attributed to more efficient total resource exploitation and greater overall production as opposed to the other intercropping treatments. This indicated that additional 0.66 m² (66%) more area would have been needed to get equal yield to planting *pechay* and spring onion in pure stands. This result is in agreement with the findings of several other intercropping studies (Sadeghi & Kazemeini, 2012; Javanmard *et al.* 2009, Temesgen and Wondimu 2012) who demonstrated the advantages of intercropping systems where, LER of greater than 1 was recorded. This might indicate that in a suitable

Table 3: Effect of spatial arrangement of *pechay*/spring onion intercropping on combined yield and land equivalent ratios of the component crops

Planting Patterns	Combined yield kg/m ²	PLER P	PLER S	TLER
2 rows of <i>pechay</i> +one row of spring onion	0.098	0.90c	0.76a	1.66b
One row of <i>pechay</i> +one row of spring onion	0.089	0.76b	0.78b	1.54b
One row of <i>pechay</i> +two rows of spring onion	0.082	0.63a	0.84c	1.47c
<i>Pechay</i> only		1d	...	1a
Spring onion only			1d	1a
CV%		17.02	11.1	20.1

Values followed by the same letter in a column are statistically similar at 0.05% level according to Duncan's multiple range tests, PLERM= partial land equivalent ratio maize, PLERP= partial land equivalent ratio potato .TLER= total land equivalent ratio

combination plants can complement each other in a more efficient use of environmental resources, mainly light, water and nutrients (Willey, 1979). The current intercropping systems demonstrate that farmers could benefit by growing the companion crops with different cropping intensity.

CONCLUSION

The experimental results have demonstrated that the sole planting of either *pechay* or spring onion results in maximum crop yield. The results imply that yield increased with increased population density of the component crops, the corresponding reduction in plant density for intercropping therefore leads to a reduction in yield. Though the reduction in plant density of each component crops led to a reduction in yield of both crops as evidenced by the partial LER (<1), the total yield of intercropped crops were greater than sole cropping as shown by TLER which were more than unity (TLER >1). This indicates the cohesiveness of the component crops under intercropping.

In this study, two rows *pechay* and one row spring onion arrangement had a 66% yield benefit over sole cropping. This indicates that compared to their cultivation in an intercropping system, 66% more area is required to produce the same yield when the two crops are grown separately. *Pechay* and spring onion are the most adaptable and a crops/vegetables as food, and cash crops. Both crops are of equal importance to the farmer because they can gain comparable economic returns, or can satisfy subsistence requirement equally. Given the unpredictable rainy season and the different water requirements of each crop, planting *pechay* and spring onion together gives the farmer a better chance that either crop will survive.

RECOMMENDATION

The study's recommendation for increasing crop production intensity is to intercrop two rows of *pechay* and one row of spring onions. The findings of this study suggest that in order to address food security in the area, agricultural policy makers and bureaus of agriculture in the region should encourage farmers to grow both crops as intercrops.

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