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Evaluation of Intercropping System for Climate Resilient Agriculture of *Yala* Season in Up Country Intermediate Zone of Sri Lanka

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Abstract

Yala season is a water scared dry period in Up Country Intermediate Zone of Sri Lanka. Majority of famers suffering with yield losses associated with unavailability of water, high temperature and hazardous winds in June to August period. To mitigate these adverse climatic conditions farmer has to select tolerant crop types. Chilli is such type of drought tolerant crop, not much proven to the wind damage and it can survive low soil water conditions while giving yield over five months. Cabbage is a short term crop very popular in Up Country vegetable cultivation system due to its lower cost of production. Therefore present study was conducted to identify suitability of cabbage to intercrop with chilli under water scared conditions. Field experiment was conducted in 2016 *yala* season in research field of Agriculture Research Station, Rahangala (IU3d) and farmer field trial conducted in 2017 *yala* season with objective of determining optimum yield and return of the intercropping system in relation to plant spacing and time of transplanting. 60 × 60 cm plant spacing for both crops has given highest yield for chilli (3.2 and 2.9 t/ha) and cabbage (70.7 and 71.9 t/ha) in both seasons. Transplanting cabbage two weeks after chilli is the best schedule for transplanting two crops. Combination of these plant spacing and time of transplanting recorded high yield, high Land Equivalent Ratio and the highest Cost Equivalent yield compared to monocrops.

Keywords: *Chilli, Intercropping, LER*

1. Introduction

Intercropping defined as the agricultural practice of cultivating two or more crops in the same space at the same time (Andrews and Kassam, 1976). When two crops are to be grown together, they are chosen in such a way that there is variation in their growth duration. The peak periods of growth of the two crop species should not coincide and the time of peak nutrient demands of component crops should not overlap. In such arrangements, a quick maturing crop completes its life cycle before the other crop starts. This can be achieved either by genetic difference in crop species or manipulation of planting dates. Normally short and long duration crops are grown together.

In Welimada area *Yala* season is water scared dry period and June to August is the driest period of the year. During this period, farmers prefer to grow drought tolerant crops like chilli for green chilli to ensure their income rather than up

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country vegetable cultivation. Chilli is a long term crop that can be harvested up to 5 months after transplanting depending on the management practices.

Cabbage is an important crop in Up Country vegetable farming system due to its cost of production is comparatively lower than other crops and its high market demand. It is a short term crop harvestable at 55-75 days after transplanting depending on the variety.

Normally chilli plant initiates its flowering at 80-90 days after planting, therefore it gives production after three months and farmer has to wait for three months without any income. Under that situation farmer need a short term second crop that can be harvested within period of three months to compensate their income while major crop attaining to production stage.

Therefore intercropping study of cabbage with chilli was carried out to determine optimum yield and return of the cropping system in relation to planting distance and time of transplanting.

2. Materials and Methods

The trial was conducted at the research field of Agriculture Research Station, Rahangala during 2016 *Yala* season and farmer field trial was conducted in Boralanda during 2017 yala season. The experimental site is located in IU3d Agro Ecological Region with Red Yellow Podsolic soil.

Cabbage was intercropped with chilli at three planting distances.

- T1- chilli 60 × 60 cm and cabbage 60 × 60 cm
- T2- chilli 60 × 90 cm and cabbage 60 × 45 cm
- T3- chilli 0 × 60 cm (single raw) and cabbage 60 cm × 45 cm

Cabbage was transplanted simultaneously and 2 weeks after the transplanting of Chilli. Each replicate was carried out with mono crop block of cabbage and chilli.

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Planting bed size was 4×1 m with 50 cm ditches between beds and 200 g of dolomite applied into each bed at two weeks before planting. 2 kg of well decomposed cattle manure added to each bed five days before planting and well incorporated.

Urea, Triple Super Phosphate (TSP) and Murate of Potash (MOP) were applied one day before planting at the rate of 110, 275 and 75 kg/ha respectively as the basal dressing recommended by the Department of Agriculture for Cabbage cultivation. Urea was applied at the rate of 110 kg/ha at 3 Weeks After Planting (WAP) and Urea and MOP applied at the rate of 110 and 75 kg/ha respectively at 6WAP in a circle around the plant and incorporated into soil.

At the stage of 12WAP Urea was applied at 125 kg/ha rate according to DOA fertilizer recommendation for chilli cultivation.

Total cabbage yield and chilli yield was recorded separately in each block and Land Equivalent Ratio (LER) was calculated using below formula defined by Mead and Willey (1980).

$$LER = L_A + L_B = (YA \div SA) + (YB \div SB)$$

L_A – LER of crop A

L_B – LER of crop B

YA- Yield of crop A in intercropping

YB- Yield of crop B in intercropping

SA- Yield of crop A in sole cropping

SB- Yield of crop B in sole cropping

The yields of different intercrops are converted into equivalent yield of chilli based on price of the produce of the crop. The Crop Equivalent Yield (CEY) is calculated by following formula given by Ahlawat and Sharma (1993).

$$CEY = \sum_{i=1}^{n} (Y_i . e_i)$$

where Y_i is yield of i^{th} component and e_i is equivalent factor of i^{th} component or price of i^{th} crop.

Data were analyzed by using ANOVA (Analysis of Variance) procedure and mean separation done by Duncan Multiple Range Test (DMRT).

3. Results and Discussion

Results of the present study indicate plant spacing, time of planting and interaction of the plant spacing and time of planting has a significant effect on the production of each crop under chilli and cabbage intercropping system in both seasons ($p < 0.05$).

Spacing combination T1 has given highest yield for both crops in both seasons (Table 1). Cabbage recorded highest yield as 70.7 t/ha and 71.9 t/ha under above spacing it is much higher than the national average production (24.9 t/ha). Chilli yield recorded (3.2 t/ha and 2.9 t/ha) under T1 spacing for both seasons, which is higher than the average green chilli production in Badulla district (2.2 t/ha). In T1 spacing arrangement both crops received lowest plant spacing rather than other treatments.

Lowest yield for both crops was recorded under T2 spacing combination, which was given cabbage yield as 54.5 t/ha and 58.1 t/ha and chilli yield as 1.4 t/ha and 2.5 t/ha.

When consider about the time of planting cabbage transplanting time has a definite effect on yield of both crops. F2 treatment has recorded highest yield for cabbage (65.7, 70.9 t/ha) and chilli (2.9 t/ha) for both seasons.

Table 1: Effect of Plant Spacing and Time of Planting on Yield of Cabbage and Chilli

Spacing	2016 *Yala*		2017 *Yala*	
	Cabbage Yield (t/ha)	Chilli Yield (t/ha)	Cabbage Yield (t/ha)	Chilli Yield (t/ha)
T1 (chilli 60 * 60 cm and cabbage 60 * 60 cm)	70.7[a]	3.2[a]	71.9[a]	2.9[a]
T2 (chilli 60 * 90 cm andcabbage 60 * 45 cm)	54.5[b]	1.4[b]	58.1[b]	2.5[b]
T3 (chilli 0 * 60 cm (single raw) and cabbage 60 *45 cm)	60.3[b]	1.5[b]	63.1[b]	2.8[ab]
Time of planting				
F1 (simultaneousplanting)	57.9[b]	2.4[b]	57.8[b]	2.5[b]
F2 (transplanting Cabbage2 weeks after Chilli)	65.7[a]	2.9[a]	70.9[a]	2.9[a]
***P* value**				
Model	0.002	0.015	0.0002	0.02
Factor 1	0.004	0.01	0.0021	0.04
Factor 2	0.025	0.03	0.0002	0.01
Fac 1 × fac 2	0.0024	0.02	0.0005	0.04
Block	0.54	0.52	0.31	0.28
CV%	10.27	13.71	7.6	8.6

Note: Within a column, means followed by the same letter are not significantly different, at $p = 0.05$.

Interaction effect (Table 2) confirmed T1 as the best plant spacing and F2 treatment is the best time of planting while recording highest yield for cabbage (84.91, 88.25 t/ha) and chilli (1.92, 3.28 t/ha) for both seasons.

According to Land Equity Ratio (LER) calculation of the present intercropping system (Table 3), R2 treatment combination has recorded highest LER for both seasons (1.818, 1.271) by further confirming T1 spacing and F2 time of planting treatments as the best treatment combination.

In 2016 *Yala* season, all the treatment combinations has given LER values higher than 1. Therefore the intercropping system has increased productivity of the land and further illustrated the yield advantage of inter over Mono cropping.

Table 2: Interaction Effect of the Plant Spacing and Time of Planting on Yield of Cabbage and Chilli

Spacing	Time of Transplanting	2016 *Yala*		2017 *Yala*	
		Cabbage Yield (t/ha)	Chilli Yield (t/ha)	Cabbage Yield (t/ha)	Chilli Yield (t/ha)
T1 (chilli 60* 60 cm and cabbage 60 * 60 cm)	F1-Simultaneous Planting	56.58	0.44	55.58	2.51
	F2-Transplanting Cabbage 2 weeks after Chilli	84.91	1.92	88.25	3.28
T2 (chilli 60 * 90 cm and cabbage 60 * 45 cm)	F1-Simultaneous Planting	55.5	0.30	56.16	2.5
	F2-Transplanting Cabbage 2 weeks after Chilli	53.45	0.44	60.12	2.51
T3 (chilli 0 * 60 cm (single raw) and cabbage 60 * 45 cm)	F1-Simultaneous Planting	61.68	0.50	61.68	2.7
	F2-Transplanting Cabbage 2 weeks after Chilli	58.87	0.42	64.54	2.9

Table 3: LER Values of the Different Treatment Combinations

Treatment	2016 *Yala*			2017 *Yala*		
	LA (Cabbage)	LB (Chilli)	LER	LA (Cabbage)	LB (Chilli)	LER
R1 (T1, F1)	0.753	0.418	1.171	0.767	0.248	1.015
R2 (T1,F2)	**0.963**	**0.855**	**1.818**	**0.998**	**0.273**	**1.271**
R3 (T2,F1)	0.738	0.371	1.109	0.743	0.23	0.973
R4 (T2,F2)	0.71	0.418	1.128	0.901	0.252	1.153
R5 (T3,F1)	0.818	0.473	1.291	0.754	0.235	0.989
R6 (T3,F2)	0.778	0.410	1.188	0.881	0.281	1.162
T7 – Chilli mono crop		1	1		1	1
T8-Cabbage mono crop	1		1	1		1

The highest LER value (1.818) in 2016 *yala* season has recorded in R2 treatment combination, which gives 81.8% yield advantage from inter crops compared to sole crops. According to that intercropping system was profitable than single cropping of Cabbage or Chilli under 2016 *yala* conditions.

In 2017 *Yala* season, LER values were greater than 1 except treatment combination R3 and R5. Highest LER value (1.271) in 2017 *Yala* season has recorded in R2 treatment combination as same as previous season, which gives 27.1% yield advantage from inter crops compared to mono crops.

According to AgStat 2018, farm gate price of Chilli is ₹227 and Cabbage ₹60 in year 2016. Based on those values, CEY calculations were done for 2016 *yala* season (Table 4). CEY value was highest (24.36) treatment combination R2, that was recorded chilli equivalent yield of cabbage is 22.44 t/ha. The lowest value (14.56) is in treatment combination R4 which recorded chilli equivalent yield of cabbage as 14.12 t/ha.

Table 4: CEY Values Under Different Treatment Combinations

Treatment	2016 *Yala* season			2017 *Yala* season		
	ChEY	ChEY of Cabbage	CEY	ChEY	ChEY of Cabbage	CEY
R1 (T1, F1)	0.44	14.95	15.39	2.51	12.99	15.50
R2 (T1, F2)	1.92	22.44	24.36	3.28	20.63	23.91
R3 (T2,F1)	0.3	14.66	14.96	2.5	13.13	15.63
R4 (T2, F2)	0.44	14.12	14.56	2.51	14.06	16.57
R5 (T3, F1)	0.5	16.30	16.80	2.7	14.42	17.12
R6 (T3, F2)	0.42	15.56	15.98	2.92	15.09	18.01

Note: ChEY- Chilli Equivalent YieldCEY-Crop Equivalent Yild.

Farm gate price of Chilli is ₹247 and Cabbage ₹58 in year 2017 (AgStat., 2018). With these prices CEY value was highest (23.91) in R2 (T1, F2) treatment combination that has chilli equivalent yield of cabbage in 20.63 t/ha. Lowest CEY value (15.5) was recorded in R1 (T1, F1) treatment combination with chilli equivalent yield of cabbage is 12.99 t/ha in 2017 *yala* season.

Conclusion

Results of the present study confirmed Cabbage intercropping with chilli in water scared *Yala* season is economically advantageous for farmers in Up Country Intermediate Zone of Sri Lanka. In this intercropping system, ideal plant spacing is 60×60 cm for both crops and best transplanting schedule is transplanting cabbage two weeks after chilli planting.

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