Agronomy Research **20**(S1), 999–1013, 2022
https://doi.org/10.15159/AR.22.020

Growth-yield performances of two chilli varieties under different agronomical components applied and their partial economic analysis

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Received: January 15th, 2022; Accepted: April 19th, 2022; Published: April 25th, 2022

Abstract. The present study had main objective to improve growth-yield performances of two curly red chilli varieties under different agronomical components (ACs) and their partial economic analysis. The research was conducted at Tampirkulon Village, Candimulyo Subdistrict, Magelang Regency, Central Java-Indonesia. The experiment was arranged in completely randomized design with six combination treatments and four replications. Two curly red chilli varieties tested were *Capsicum annum* L. 'Kencana' and 'OR Twist 42'. Three different ACs investigated were (1) Indonesian Vegetable Research Institute (IVegRI) ACs, (2) farmer ACs, and (3) low-agro input and environmental-friendly (Lai-ef) ACs. Results of the study reveal that growth-yield of chilli were significantly improved due to utilization of healthy seedlings, 'OR Twist 42' variety and IVegRI ACs. The seedlings increased number of flowers and fruit plant^{-1} up to 24.9% and 14.2%; 23.6% and 19.5% induced by 'OR Twist 42'; and 54.5% and 25.5% stimulated by IVegRI ACs. Combination of 'OR Twist 42' and IVegRI ACs was the optimal combination treatment in improving growth-yield performances of the curly red chilli with as high as 279.2 fruits per plant, 1,111.4 g chilli productivity fruit plant^{-1}, 167 kg chilli productivity plant^{-1} with 40.6, 39.9, and 33.3% improvement compared to farmer ACs. The combination had Return Cost (R/C) ratio with as high as 2.04. Lai-ef ACs was another interesting result with 1.90 R/C ratio due to low agro-input cost compared to the farmer ACs with as low as 1.64. These results clearly contributed to a better understanding the effect of utilizing healthy seedlings, high adaptive-productive variety and optimal ACs individually or in combination on improving growth-yield of chilli.

Key words: agronomical component, chilli, growth, variety, and yield.

Used abbreviations: ACs – agronomical components; ANOVA-analysis of variance; *CV* – coefficient of variation; DAP – day after planting; IVeGRI – Indonesian Vegetable Research Institute; Lai-ef – low-agro input and environmental-friendly; KCl – potassium chloride; KNO_3 – potassium nitrate; NPK – nitrogen phosphor potassium; SP36 – super

phosphate; R/C ratio – Return cost ratio; TSP-triple super phosphate, V1T1, 'Kencana' planted using IVegRI ACs; V1T2, 'Kencana' cultivated using farmer ACs; V1T3, 'Kencana' grown under lai-ef ACs; V2T1, 'OR Twist 42' planted using IVegRI ACs; V2T2, 'OR Twist 42' cultivated using farmer ACs; V2T3, 'OR Twist 42' grown under lai-ef ACs.

INTRODUCTION

Chilli (*Capsicum annum* L.) are strategic and important vegetable commodity in Indonesia due to each alteration of the chilli price affecting the national economy growth. In October 2020 due to rainy season effect, increasing chilli price induced national inflation as high as 0.07% (Pryanka, 2020). The commodity is widely cultivated in all Indonesian provinces with Central Java as main production areas (Statistic Indonesia, 2021a) with 2.6 million tons total production in 2019 (Statistic Indonesia, 2021b). Return Cost ratio (R/C ratio) of the chilli agribusiness varied from 1.93 to 2.83 (Maharti et al., 2019; Astining & Bangun, 2020) with selling product from 4,000 to 60,000 rupiahs in farmer level (Mahardhika, 2020). Though the commodity was important and has high economic value, low productivity is still serious problem faced (Statistic Indonesia, 2021c), especially noted in Central Java province with as low as 6.45 tons ha^{-1} (Statistics of Jawa Tengah Province. 2020). Therefore, improving chilli growth and yield performances shall be addressed.

In chilli cultivation, optimal growth and yield performances of the plants are significantly affected by various factors *viz*, the use of varieties and their seed nurseries (Kesumawati et al., 2019; Syafruddin et al., 2019), plant spacing and density (Sharma & Kumar, 2017; Ansa & Woke, 2018), soil processing and application of basic and supplement fertilizers both organic and inorganic materials (Islam et al., 2018; Mahmud et al., 2019; Valenzuela-García et al., 2019), plastic mulch (Yartawi & Yahumri, 2015), and physical barrier (Salas et al., 2015). Combination of two factors as reported by (Bhuvaneswari et al., 2014; Salas et al., 2015; Yartawi & Yahumri, 2015; Sharma & Kumar, 2017; Kesumawati et al., 2019; Valenzuela-García et al., 2019; Putra et al., 2020) were generally applied to increase the chilli growth and productivity, while combining several factors to establish optimal results are not researched yet previously.

Combining several factors to stimulate maximal growth and yield of chilli and application of low agro-input and environmentally friendly technology or Lai-ef/organic farming were a few reported. Raziliano et al. (2015) reported that application of 12 g $plot^{-1}$ sawdust ash in combination with 100 g $plot^{-1}$ Urea, 200 g $plot^{-1}$ triple super phosphate or TSP and 160 g $plot^{-1}$ potassium chloride or KCl resulted in optimal growth and yield of 'TM999' variety as high as 1,180.3 g $plot^{-1}$. Combination treatment of Lado F1 variety fertilized with 75 kg ha^{-1} urea, 75 kg ha^{-1} super phosphate 36 or SP36, 75 kg ha^{-1} KCl with addition of 1.35 kg compost per planting hole induced the highest results of chilli fruits up to 253.4 g $plot^{-1}$ (Anggraheni et al., 2019). Through the organic farming, 'Lado F1' variety gave higher productivity up to 627.9 g $plot^{-1}$ than 'Perintis' variety (Syafruddin et al., 2019), 'Bemeri' variety had high number of fruits per plant till 8.4 fruits compared to 'Kopay' and 'Perintis' variety (Kesumawati et al., 2019). Utilization of 3 tons ha^{-1} vermicompost increased productivity of 'Pusa Jawala' variety up to 20.1 tons ha^{-1} (Bilal et al., 2019). Using mountain microorganisms as bio-activator in horse manure decomposition and biopesticide successfully improved chilli yield up to 21.5 tons ha^{-1} (Liferdi et al., 2020). While application of IVegRI technology in

comparison to farmer and lai-ef ACs which emphasize on utilizing different varieties such as 'Kencana' and 'OR Twist 42' is not reported yet.

Valuable information's derived from research on improving growth-yield performances of two churly chilli varieties under different ACs and their partial economic analysis in Central Java Indonesia as main objective were successfully proved. Application of IVegRI and lai-ef ACs for 'Kencana' and 'OR Twist 42' variety promoted interesting and significant results compared to the farmer ACs in all aspects. The interesting results were discussed in detail in the paper.

MATERIALS AND METHODS

Experimental site and soil condition

The experimental site was in Tampirkulon Village, Candimulyo Subdistrict, Magelang Regency, Central Java Province-Indonesia from March to August 2020. The location altitude was 327 meters above sea level with fluctuated amount of precipitation from 0 to 516 mm per month and 131 mm in average per month; air temperature and humidity were 28–34 °C and 70–95% during the day and 22–26 °C and 47–68% during the night, respectively. Soil characteristics of research farm had loam texture class with 41.06% sand, 41.64% silt, 17.30% clay and 5.85 soil pH. Application of dolomite 2.8 kg m^{-2} was carried out to increase soil pH suitable for chilli growth. The soil characteristics above were used to investigate three different ACs either IVegRI, farmer or lai-ef ACs in combination with utilization of two different varieties of 'Kencana' and 'OR Twist 42'. Different responses in conjunction to find the best treatment derived from the two combination treatments between ACs and varieties expected would be established in the research.

Nursery practice

Healthy seedlings were prepared by immersing seeds of 'Kencana' and 'OR Twist 42' variety in warm water at 60 °C in closed-jar added by 1 mm L^{-1} propamocarb hydrochloride for 2 hours. After 2 hours, the seeds were air-dried on the paper, then planted in mixture media of fine bamboo soil and organic manure (1:1, v/v) in small plastics watered sufficiently and placed in bamboo trays (± 400 seeds). Each hole was planted with one seed, covered by fine organic manure in 1 cm in thickness, placed in sterile insect proof screen from pests and diseases, covered by plastic net and mulch for 7 days, watered regularly and fertilized after 20 days after planting (DAP) in half dosage. Three weeks after seed sowing, the chilli seedlings were pruned and left 2 cotyledon leaves. After lateral shoots growth with one normal leaf, the seedlings were treated by organic inducer containing pagoda leaf extract to protect against Gemini virus and 5 days later, the seedlings were then planted in the planting beds. While farmer seedlings, the seeds were directly planted in planting medium as previously mention without any treatments and maintained under plastic screen by watering and fertilizing till the seedlings ready planted in the similar old as healthy seedlings.

Land and planting bed preparation

Whole experimental area was cleared from rest of rice straw and grasses using lawn mower. The cut rice straw and grasses were moved from the experimental area. The experimental land was then tilled using hand tractor and left for 2 weeks. After two

weeks, the research farm was processed and fertilized manually as each ACs tested using hoes. In application of fertilizers, all fertilizers in each ACs were homogeny mixed maximally, then poured evenly in two long holes with 50 cm distance between them in each plant bed. Farmer ACs beds with 1×16 m in size and 1×12 m beds for IVegRI and lai-ef ACs were then constructed. In farmer ACs, each plot consisted of 6 beds and 4 beds with bed borders for IVegRI and lai-ef ACs. Distance between beds was 50 cm, 100 cm between experimental plots and 200 cm between replications.

Preparing plant border

Plant border used for IVegRI and lai-ef ACs was corn plants. The border was prepared by culturing corn seeds with 20×20 cm planting distance in zig-zag model. The seeds were planted in 2 cm in depth. Each hole was put one seed then covered again using media. During the experiment, the plant border was cultured twice. Meanwhile, in farmer ACs did not use the plant borders.

Planting chilli seedlings

In farmer ACs with 50×50 cm in plant spacing, each hole with ± 5 cm in depth and diameter put one seedling and covered again by media was applied. While for IVegRI and lai-ef ACs, 50×70 cm in plant spacing was utilized. In 50 cm the plant spacing, one hole one seedling was practiced, but in 70 cm spacing, one wider hole with two seedlings cultured was applied.

Plant maintenance

The chilli plants were watered regularly and sufficiently. Regular weed clearing and pest-disease controlling were carried out regularly. For farmer ACs, pests and diseases attacking chilli plants were totally controlled using synthetic pesticides; 50% synthetic pesticides; 50% biopesticides for the IVegRI ACs; and 100% biopesticides for lai-ef ACs.

Experimental design and treatments

The experiment was arranged in completely randomized design with six combinations of two curly red chilli varieties and three ACs and four replications. The chilli varieties i.e., (1) *C. annum* 'Kencana' (V1) and (2) 'OR Twist 42' (V2) and three ACs (1) IVegRI ACs (T1), (2) farmer ACs (T2) and (3) Lai-ef ACs (T3) were used in the study (Table 1).

Experiment variables

The variables observed in the experiment were (1) plant height (cm); measured from base of stem till growth point (2) main branching height of plant (cm); quantified from the base of the stem till main branching position determined, (3) stem diameter (mm); calculated in the base of the stem using digital caliper, (4) canopy width (cm); assessed in the middle position of canopy, (5) number of flowers plant^{-1}, (6) weight of fruit fruit^{-1} (g); weighed using digital balance, (7) yield of chilli plant^{-1} (g), (8) chilli productivity plant^{-1} (g); counted from average of fruit weight timed by number of fruits harvested plant^{-1}, (9) chilli productivity plot^{-1} (kg); calculated by multiplying average productivity plant^{-1} with total number of plants plot^{-1}. Periodical observation was conducted to know growth responses of chilli plants starting from initial planting till final harvest.

Table 1. Different agro-inputs of the three ACs tested in the research

No.	Agro-input	IVegRI ACs (T1)	Farmer ACs (T2)	Lai-ef ACs (T3)
1.	Type of seedling	- Healthy seedlings	- Farmer seedlings	- Healthy seedlings
2.	Plant population	- 30,000 plants ha^{-1}	- 20,000 plants ha^{-1}	- 30,000 plants ha^{-1}
3.	Plant spacing	- 50×70 cm	- 50×50 cm	- 50×70 cm
4.	Basic fertilizers	- 20 tons ha^{-1} of fermented-chicken manure, 200 g ha^{-1} Bionutrient, 500 tons ha^{-1} NPK 16:16:16, 200 tons ha^{-1} ZA, and 0.5 kg per 100 liter humic acid	- 12.5 tons ha^{-1} of fermented chicken manure, 750 black NPK, 750 TSP/SP 36	- 20 of fermented-chicken manure, 200 g ha^{-1} Agrimeth, 20 kg ha^{-1} Gliocompost, and 10 mL L^{-1} per m^2 PGPR
5.	Supplement fertilizer	- 0.5 kg humid acid; dissolved in 100 liters of water; applied 200 mL $plant^{-1}$ in 20 days after planting (DAP) - 1 kg NPK 16:16:16; dissolved in 100 liters of water; applied 200 mL $plant^{-1}$ every 10 days periodically after 1 month of planting till final harvest times - 0.5 kg red KNO3; dissolved in 100 liters of water; applied 200 mL $plant^{-1}$ twice at 30 and 50 DAP - 0.5 kg red KNO3; dissolved in 100 liters of water; applied 200 mL $plant^{-1}$ twice at 60 and 80 DAP	- 1 kg NPK Maroke and 1 kg white KNO_3; dissolved in 200 liters of water; applied 200 mL $plant^{-1}$ every 10 days periodically till final harvest period	- 100 mL PGPR, 2 kg Gliocompost, 0.5 kg humid acid; dissolved in 100 liters of water; applied 200 mL $plant^{-1}$ every 15 days till final harvest period. - 100 mL Bionutri-V; dissolved in 100 liters; applied 200 mL $plant^{-1}$ every 10 days till initial fruit formation. In the next step 100 mL Bionutri-V, 100 mL Bionutri-G; dissolved in 100 liters; applied 200 mL $plant^{-1}$ every 10 days till harvest period
6.	Plastic mulch	- Plastic mulch applied	- No plastic much utilized	- Plastic mulch applied
7.	Physical Border	- Physical border applied	- No physical border applied	- Physical border utilized

Taking and measuring all variables were carried out regularly following the growth and development of chilli plants. Furthermore, to determine farming efficiency derived from the effect of varieties and ACs in terms of revenue and production costs, return cost (R/C) ratio was calculated as described by Rambe et al. (2021). R/C ratio = Total Revenue (TR)/Total Cost (TC). If the R/C ratio is > 1, the farming system is said to be efficient; if the R/C ratio = 1, then the farm experiences is at the break-even point status; and if the R/C ratio < 1, then the farming system is inefficient. The production costs were calculated by compilating all factors affecting the costs such as seeds, fertilizers, pesticides, labor costs, etc.

Data analysis

Quantitative data in the experiment were analyzed by analysis of variance (ANOVA) using SAS Release Windows 9.1 (SAS Institute, Cary, NC). Significant differences between means were assessed by Tukey test, $P = 0.05$ (Mattjik & Sumertajaya, 2006).

RESULTS AND DISCUSSION

Based on periodical observations it was revealed that initial flowering was generally noted ± 22 DAP when the chilli plants had 24.9–34.9 cm in height and ± 28.2 cm in width of plant canopy. Initial fruits were recorded 42 DAP when the chilli plants had 61.6–66.2 cm in height and ± 32.5–38.9 cm in width of plant canopy. Pick flower number/plant was observed on 65–72 DAP and 79 DAP for fruit number produced plant^{-1}.

Utilization of the healthy seedlings derived from 'Kencana' and 'OR Twist 42', in fact, had significant improvement on growth-yield of chili. The significant improvement was noted based on number of flowers plant^{-1} (Fig. 1, A) and number of fruits plant^{-1} (Fig. 1, B) compared to farmer seedlings. The seedlings increased number of flowers per plant up to 24.9% and 14.2% for number of fruits plant^{-1}. Furthermore, utilization of 'OR Twist 42' variety had higher and better results compared to 'Kencana' variety with higher number of flowers plant^{-1} up to 23.6% (Fig. 1, C) and 19.5% number of fruits plant^{-1} (Fig. 1, D) than 'Kencana' variety. While IVegRI ACs increased 54.5% number of chilli flowers plant^{-1} (Fig. 1, E) and 25.5% for number of fruits plant^{-1} (Fig. 1, F). From the research it was determined that growth and yield performances of the two chilli varieties tested were significantly influenced by utilization of seedling types, varieties and ACs applied.

Optimal combination treatments give significant effect on growth-yield performances of chillies. 'OR Twist 42' planted using IVegRI ACs were the most appropriate combination in finding the optimal results. The combination was able to stimulate the growth of chilli plants up to 120 cm in height with 14.6 mm stem diameter; 88 cm plant canopy width; 400.8 number of flowers plant^{-1}; 3.98 g fruit weight fruit^{-1}; 279.2 number of fruits plant^{-1}; 1,111.4 g of fruit productivity per plant and 167 kg of chilli productivity plot^{-1} (Table 2; Fig. 2, B). The combination treatment was also able to increase number of fruits per plant up to 40.6%; 36.7% fruit productivity per plant and 26% chilli productivity plot^{-1} compared to others (Fig. 2, A). The second-best combination was shown by the 'OR Twist 42' cultivated using the farmer ACs (Fig. 2, D). Furthermore, the 'Kencana' variety, which was grown using the IVegRI

ACs, was not able to increase the productivity of chillies. In the 'Kencana' variety, the varieties planted with the farmer ACs gave the best results compared to other combinations (Fig. 4, A and 2, C).

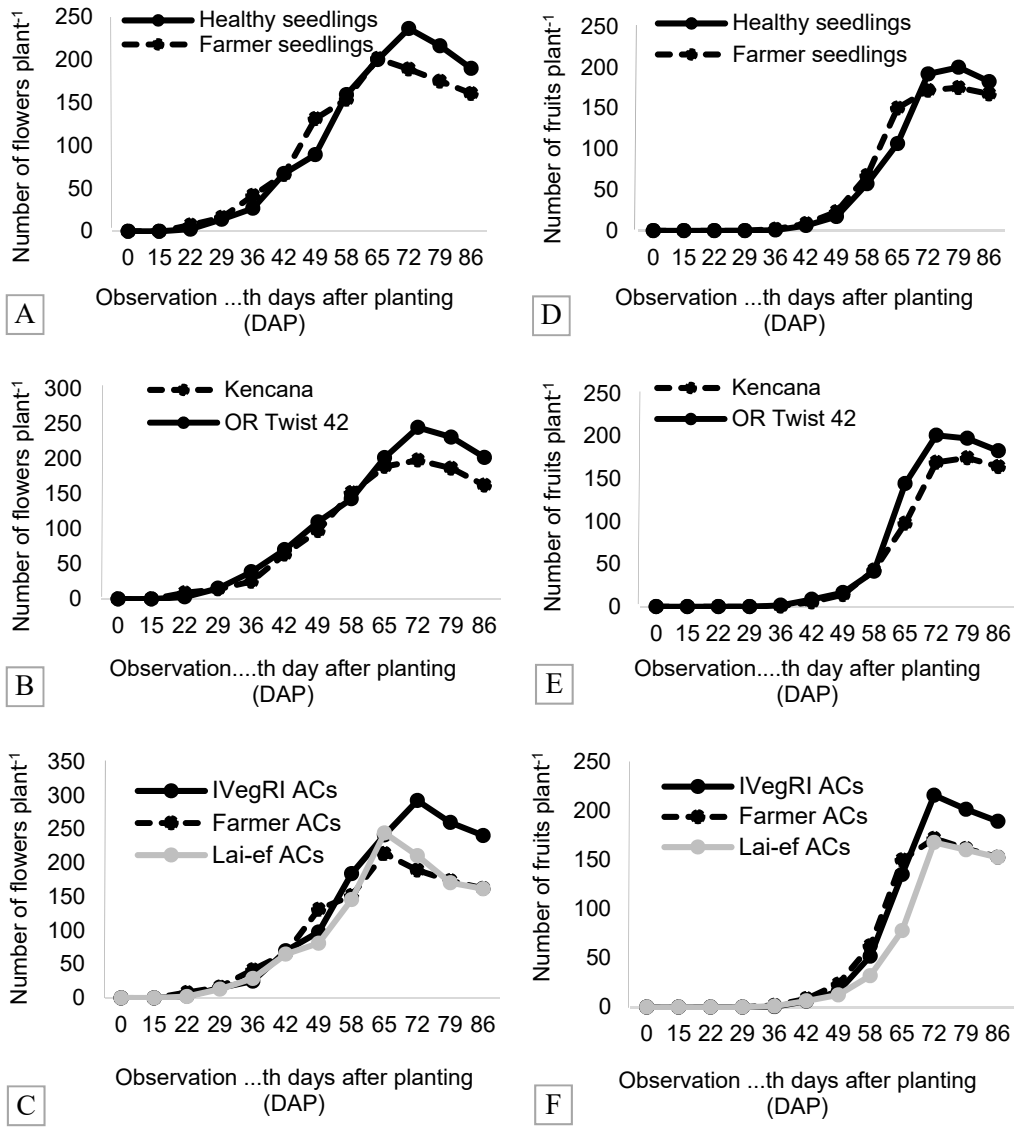

Figure 1. The effect of seedlings, varieties and ACs on growth-yield performances of curly chillies from initial planting till 86 DAP. Gradual alteration of flower number plant^{-1} affected by the seedlings (A), varieties (B) and ACs (C). Gradual changing fruit number plant^{-1} affected by the seedlings (D), varieties (E) and ACs (F).

Table 2. The effect of combination treatment of varieties (V) and ACs (T) on growth-yield performances of curly red chillies

Combination of Treatment	Plant height (cm)	Main branching height (cm)	Stem diameter (mm)	Plant canopy width (cm)	Number of flowers plant^{-1}	Weight of fruit per fruit (g)	Number of fruits plant^{-1}	Fruit productivity plant^{-1} (g)	Chilli productivity plot^{-1} (kg)
V1T1	87.9 bcd	2.9 c	12.9 ab	71.2 bcd	290.5 ab	3.01 b	200.4 b	610.4 bc	80.1 c
V1T2	73.9 d	34.2 b	12.3 b	62.2 d	287.6 ab	3.46 ab	185.8 b	640.6 bc	94.4 c
V1T3	85.8 cd	3.0 c	11.4 b	65.0 cd	224.3 b	2.95 b	158.8 b	468.2 c	56.2 d
V2T1	120.0 a	3,4 c	14.6 a	88.0 a	400.8 a	3.98 a	279.2 a	1,111.4 a	167.0 a
V2T2	95.5 bc	40.9 a	12.4 b	79.6 ab	279.7 ab	4.00 a	198.6 b	794.4 b	125.3 b
V2T3	104.6 ab	3.6 c	11.9 b	74.6 bc	230.1 b	3.76 a	170.4 b	642.0 bc	85.2 c
Coefficient of variation (*CV*, %)	6.92	11, 12	5.16	4.95	17.48	7.36	9.04	11.04	10.67

Means followed by the same letter in the same column are no significant difference based on Tukey's test, $P = 0.05$. V1T1, 'Kencana' planted using IVegRI ACs; V1T2, 'Kencana' cultivated using farmer ACs; V1T3, 'Kencana' grown under lai-ef ACs; V2T1, 'OR Twist 42' planted using IVegRI ACs; V2T2, 'OR Twist 42' cultivated using farmer ACs; V2T3, 'OR Twist 42' grown under lai-ef ACs.

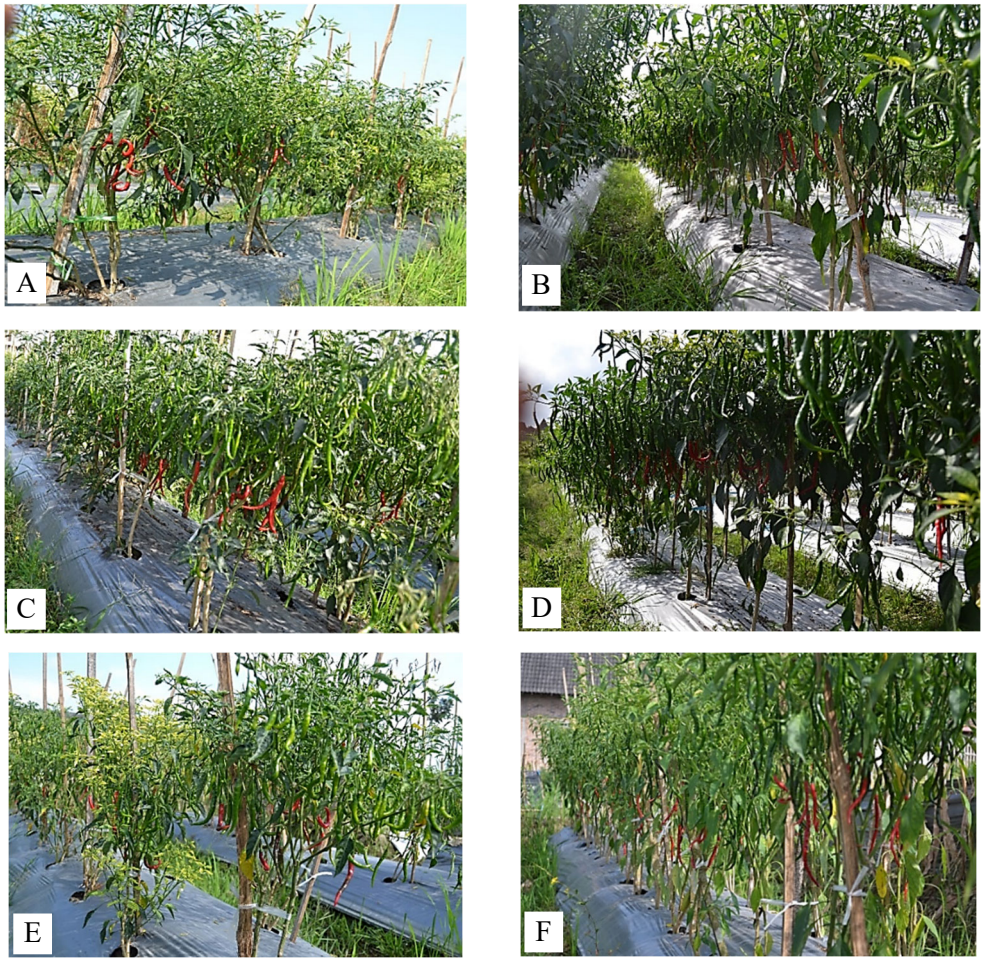

Figure 2. Performances of two curly chilli varieties of cultivated under different ACs. A. 'Kencana' planted using IVegRI ACs, B. 'OR Twist 42' planted using IVegRI ACs, C. 'Kencana' cultivated using farmer ACs, D. 'OR Twist 42' cultivated using farmer ACs, E. 'Kencana' grown under lai-ef ACs and F. 'OR Twist 42' grown under lai-ef ACs.

During harvest periods for 21 times, selling price of chillies kg^{-1} was fluctuated from Rp. 7,500 to 25,000 kg^{-1} with Rp. 15,700 kg^{-1} in average. Furthermore, under simple economic analysis to determine farming efficiency based on total revenue and production costs, most of combination treatments generally were in efficient status with the R/C ratios varied from 0.97 to 2.04 (Table 3). From the 2 varieties used, the 'OR Twist 42' variety showed higher R/C ratio than 'Kencana' in all combinations. From the 6 treatment combinations, 'OR Twist 42' planted under IVegRI ACs had the highest R/C ratio up to 2.04 with increasing percentage of farmer income up to 24.4%. The second-best result with 1.90 was actually exhibited by the 'OR Twist 42' cultivated using lai-ef ACs. These results provided evidence that though lai-ef ACs did not give significant effect on growth-yield performances of chilli, due to low agro-input cost, the ACs was able to provide better benefits than the farmer ACs with improving farmer income up to 15.9%.

Table 3. Simple economic analysis of the effect of 6 treatment combinations on the R/C ratio

Combination of treatment	Total production cost plot^{-1*} (Rp)	Total chilli production plot^{-1} (kg)	Total revenue plot^{-1} (Rp)	R/C ratio
V1T1	1,286,511.3	80.1	1,256,000	0.97
V1T2	1,199,843.3	94.4	1,482,080	1.24
V1T3	726,549.2	56.2	882,340	1.21
V2T1	1,286,511.3	167.0	2,621,900	2.04
V2T2	1,199,843.3	125.3	1,967,210	1.64
V2T3	726,549.2	85.2	1,337,640	1.90

*Note: each plot had size 16 m in length and 8 m in width equal with 128 m^2.

Overall from the study, it was successfully explored that optimal growth-yield performances of chilli were significantly affected by utilization of healthy seedling, productive-adaptive variety, suitable cultivation ACs and their combinations. Under the observation, utilization of healthy seedlings of 'Kencana' and 'OR Twist 42' improved number of flowers plant^{-1} up to 236.8 flowers (24.9%) (Fig. 1, A) and number of fruits plant^{-1} up to 200.1 fruits (14.2%) (Fig. 1, B) compared to farmer seedlings. In other studies, the healthy seedlings of 'TM 999' variety stimulated 124.5 fruits per plant and increased number of fruits up to 21.8% compared to normal seedlings (Yuda et al., 2018), 228.5 flowers plant^{-1} and 124.5 fruits plant^{-1} of 'Kastilo' variety (Setiawati et al., 2018); and 101.8 fruits per plant with 18.6% improvement compared to farmer method (Atman et al., 2021). The above results confirmed that application of healthy seedlings improved chilli productivity significantly.

High adaptivity and productivity of chilli varieties are one of important factors usually applied in establishing optimal growth-yield performances of chilli. From the study it was clearly revealed that 'OR Twist 42' variety enhanced number of flowers plant^{-1} up to 23.6% (244.3 flowers) with 19.5% fruits plant^{-1} (201.2 fruits) than 'Kencana' with 197.7 flowers and 174.7 fruits, respectively. In other studies, 'Kajoli' variety was the most appropriate variety compared to 'Vadaria'>'Magura'>'Bogra Morich' variety with 265.5 fruits plant^{-1} (Chowdhury et al., 2015), 327 fruits plant^{-1} of 'Kajoli' than 'Akashi'>'Deshi Kacha Morich'>'Bogra Morich'>'Dongfou' variety with 8–200% improvement (Chowdhury et al., 2020). 'Lado' variety had high productivity up to 198 fruits per plant and 11.9% enhancing compared to 'Perintis' variety (Syafruddin et al., 2019). 'High Fly' variety produced high number fruits per plant up to 52.5 flowers and 184.6 g plant^{-1} than 'Magma' variety with 10.7% increment (Jan et al., 2020). These results proved that utilization of suitable variety gave high effect on chilli productivity established.

Suitable cultivation ACs had closely relation to quality and productivity of chillies. IVegRI ACs with several components (Table 2) increased number of chilli flowers per plant up to 54.5% and 25.5% for number of fruits per plant with 292.7 flowers plant^{-1} and 216 fruits plant^{-1}, respectively. In different studies, 25 farm yard manure in combination to 300 kg ha^{-1} urea, 60 kg ha^{-1} single super phosphate and 120 kg ha^{-1} muriate of potash induced high number of fruits plant^{-1} up to 94 fruits and 600 g plant^{-1} fresh fruit yield for 'Wgl Chapata' with 54.1% and 81% increasing, respectively (Srinivas et al., 2017). 10 ml L^{-1} biofertilizer, 1.5 kg ha^{-1} magnesium and 1.5 kg ha^{-1} boron improved productivity of chilli up to 54.5% compared to other treatments (Setiawati et al., 2020). 0.05% copper with standard N, P, K concentrations added

treatment stimulated high number of pots per plant up to 47 pots, 109 g plant^{-1} yield with 25% yield increment compared to control treatment (Thennakoon et al., 2020). From these results, it was proved that suitable ACs applied in chilli cultivation leading to optimal plant productivity achieved.

Suitable combination treatments generally stimulate optimal growth and yield performances of plant. In the research, 'OR Twist 42' variety cultivated under IVegRI ACs induced number of fruits plant^{-1} as high as 279.2 fruits with 1,111.4 g of fruit productivity plant^{-1} and 167 kg of chilli productivity plot^{-1} with 40.6, 36.7 and 26% improvement, respectively. In different researches, combined application of 100 kg ha^{-1} of phosphorous and120 kg ha^{-1} of potassium for exotic land race of chilli was the optimal combination in producing 90.8 flowers plant^{-1}, 30.2 fruits per plant , and 465.5 g fruit plant^{-1} with 114.6%, 115.5% and 94.4% of improvement, respectively (Akram et al., 2017). Combined application of 135 kg ha^{-1} urea with 4.5 cow dung for 'California' variety showed significant increase in number of fruits plant^{-1} up to 16.6 fruits with 142.1 g fruit weight, and 38.5 kg replicate^{-1} with 88.6%, 22.2% and 80.8% of increasing percentage of them, respectively (Islam et al., 2017). Combination treatment of 'Lado F1' variety fertilized with urea 75 kg ha^{-1}, SP36 75 kg ha^{-1}, KCl 75 kg ha^{-1} with addition of 1.35 kg compost planting per hole resulted in high chilli productivity up to 253.35 g plant^{-1} (Anggraheni et al., 2019).

Under efficient farming, higher R/C ratio achieved, higher profit established. Combined application of organic and inorganic fertilizers (NPK, Urea, ZA, KCl) for hot chilli established R/C ratio up to 2.03 (Ardian et al., 2017). Application of organic chicken manure in combination with the inorganic fertilizers for 'Hot Beauty' variety resulted 3.05 R/C ratio (Iwan et al., 2017), 2.26 R/C ratio for 'Helix' variety (Sutardi & Wirasti, 2017). Combined utilization of basic fertilizers of 400 kg ha^{-1} of urea, 200 kg ha^{-1} of SP-36, 250 kg ha^{-1} of KCl applied to the soil and 0.5 kg ha^{-1} HF foliar fertilizer for 'TM999' variety had R/C ratio as high as 1.95 (Sugiyanta et al., 2018). Though utilization of local variety cultivated under the IVegRI ACs resulted in high R/C ratio up to 3.27 (Rambe et al., 2021). In the study, 'OR Twist 42' variety in combination with IVegRI ACs had R/C ratio up to 2.04 with 24.4% farmer profit improvement. These results clearly revealed that the all combination treatments induced efficient farming with high R/C ratio.

Interesting result was determined in the study due application of lai-ef ACs in combination with utilization of 'OR Twist 42' variety. Due to low agro input practiced, the combination stimulated higher R/C ratio as high as 1.90 than the farmer ACs combined with the 'OR Twist 42' variety that had R/C ratio as low as 1.64. High R/C ratio due to application of low agro input that generally used organic materials was also noted on curly red chilli with 2.19 (Qomariah & Pramudyani, 2014), hot chilli with 2.45 (Lestari et al., 2018), 'TM999' variety with 1.95 (Sugiyanto et al., 2018). From the information it was clear that though application of low agro input for chilli did not produce high productivity on chilli, the ACs generally regenerated higher R/C ratio compared to the farmer ACs with 15.9% farmer profit increasing.

CONCLUSIONS

The outstanding improvement of growth-yield of chilli was established derived from the study. Firstly, utilization of healthy seedlings actually improved growth-yield of chilli in all variables observed. The results confirmed that application of healthy seedlings significantly improved chilli growth and productivity. Secondly, high adaptivity and productivity of chilli varieties, high chilli growth-yield established. In the study 'OR Twist 42' was better than 'Kencana' varieties. These results proved that utilization of suitable variety gave high effect on chilli productivity. Thirdly, high suitability ACs in chilli cultivation led to optimal growth-yield of chilli that was also established with IVegRI ACs in the study. Suitable ACs applied in chilli cultivation led to optimal plant productivity achieved. Fourthly, the best combination treatment to stimulate optimal growth and yield performances of chilli was also established in the study by planting 'OR Twist 42' under IvegRI ACs. The evident proved that suitable combination treatment led to growth-yield improvement of chilli. Finally, high efficient farming under optimal combination treatment brought higher R/C ratio up to 2.04 due to maximal growth and high productivity compared to other combinations. While higher R/C ratio up to 1.90 derived from 'OR Twist 42' variety cultivated under lai-ef ACs due to low agro-input used in the combination than farmer ACs. The data determined that high R/C ratio was established due to maximal growth and productivity and low agro-input used. Summarizing, these data contribute to a better understanding the effect of the seedling types, chilli varieties, ACs and their suitable combination treatment utilized and applied for the optimal growth-yield of chilli was clearly established in the study by utilization of healthy seedlings of 'OR Twist 42' variety cultivated under IVegRI ACs. The suitable combination treatment led to high chilli productivity and profit.

ACKNOWLEDGMENTS. We express our gratitude to the Central Java Assessment Institute for Agriculture Technology for facilitating and funding to carry out the research activity under 2020 Research Grand under DIPA-018.09.2.567318/2020. We would like to express our deepest appreciation to Widodo Guritno for renting irrigated-land for research at Tampirkulon, Candimulyo, Magelang Regency; to Heri Sutiyanto, Karsono, Mulyono, Mul Parji and Prayitno for their supporting during the research activities technically; and to Dian Dini, Endah Winarni and Suharno for assistance in performing the measurements.

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