RESPONSE OF PADDY RICE UNDER SYSTEM OF RICE INTENSIFICATION

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Abstract
Field experiment was conducted in October 2014 until January 2015, at Pasar Melintang Village, Deli Serdang regency, North Sumatra, Indonesia, with elevation of 26 m above sea level, wet tropical climate, on sandy loam, pH 5.6. The purpose of this study was to investigate the response of paddy rice on plant spacing and seedling age under System of Rice Intensification. The experimental design was Randomized Completely Block Design Factorial with two factors. The first factor was two different ages of seedlings [8 days old (U1) and 12 days old (U2)]. Second factor was four different of plant spacings [25 cm x 25 cm (J1), 30 cm x 30 cm (J2), 35 cm x 35 cm (J3), and 40 cm x 40 cm (J4)]. The results showed that there was no effect of seedling age on paddy rice growth and yield. However, plant spacing significantly affected the growth and yield, except the height and stem diameter.

Key words: System of Rice Intensification, seedling age, plant spacing, days after planting, rice Ciherang.

INTRODUCTION

Indonesia ranks third in rice production in the world after China and India. Rice (*Oryza sativa* L.) is the staple cereal food grain in Indonesia for more than 90% Indonesian population consumes rice, provides more than 70% national caloric needs. Rice is cultivated by more than 90% of small subsistence farmers, rice is a main source income of more than 60% Indonesian population, so that rice is considered as a strategic commodity (GANI AND WIDARTA, 2009). Therefore, Indonesian government has put much efforts to develop a technology that can improve the productivity of rice in oder to meet the population need on rice.
The Green Revolution was the fundamental changes in the cultivation technology of rice that began in the 1950s and 1980s in many developing countries in Asia, included, Indonesia. The Green Revolution based on four important pillars namely the provision of water through irrigation systems (soil saturated), optimal use of chemical fertilizers, pesticides application in accordance with the level of pest attacks, and the use of high yielding varieties (SISWORO, 2007). Cultivation practices with Green revolution, the paddy fields continously saturated, planted 3 to 5 seedlings per planting hole, with the age of seedlings of 21 days old, plant spacing 20 cm x 20 cm and applied high external input, such as chemical ferlizers and chemical pesticides. Through this system, increased rice yields and enable cultivation doubled, even three times a year for rice in certain places, something that previously was not possible. The positive impact of the green revolution in Indonesia was production of rice increased. For example: Indonesia from a rice importer is able to self-sufficiency and to export rice to India from 1984 – 1989. However, The Green Revolution has received criticism in line with the increasing awareness of environmental sustainability because it caused severe environmental damage. Some problems and negative impacts of green revolution: the decline of biodiversity, continues use of fertilizers cause dependence of plant on fertilizer, and the excessive use of pesticides led to the emergence of new strains of resistant pests (ANDERSON AND HAZEL, 1985).
The possible way to increase the productivity is through formulating better production technologies with improved cultivars and efficient nutrient management practices. The System of Rice Intensification (SRI) was was originally developed in Madagascar between 1983-1984 (RANJITHA ET AL., 2013). SRI practices mainly based on six components: (1) transplanting of young seedlings, (2) transplanting of single seedling, (3) wide plant spacing, (4) aerobic soil moisture, (5) only compost application, and (6) weeding (STOOP ET AL., 2002). In Indonesia SRI concept was also tested and practiced at some districts in Java, Sumatera, Bali, West Nusa Tenggara, Kalimantan, Sulawesi and Papua. (ANUGRAH ET AL., 2008). However, since the concept of SRI is a pure organic farming, farmers in the area of research is very difficult to implement SRI 100%, due to the availability of organic materials, including organic fertilizers and organic pesticides to meet the need of rice are very unlikely to be implemented. Economically, if the SRI implemented 100% accordingly it would cost much higher than

conventional system that the farmer implemented. Some researches that applied some concepts of SRI such as Kumar et al. (invited paper) applied SRI method at 25 locations for four years across India found clearly indicated that SRI resulted 7 – 20 percent higher grain yield over the traditional irrigated transplanted rice, reduced the seed rate by 80%, water requirement by 29% and growth duration by 8 – 12 days. JONHARNAS ET AL. (2003) found that the number of seedlings per planting hole did not affect the productivity of four paddy varieties. Research conducted by SEMBIRING ET AL. (2003) showed that the seedlings number and seedling age did not affect the productivity of rice. According to SALAHUDDIN ET AL. (2009) that plant spacing affected panicle length, number of grain per panicle and yield. PANDIANGAN ET AL. (2014) recorded that plant spacing with 35 cm x 35 cm of rice cultivar IR-64 resulted the highest yield compared with plant spacings of 25 cm x 25 cm, 30 cm x 30 cm and 40 cm x 40 cm. NAIDU ET AL. (2013) found that transplanting of 12 days old seedlings resulted in the highest grain yield, grain protein and N P K uptake compared with 8, 16, 20 days old seedlings and planting pattern of 25 cm x 25 cm recorded higher grain yield, grain protein and N P K uptake compared with 20 cm x 20 cm, 30 cm x 30 cm and 35 cm x 35 cm. while these parameters were lowest with planting pattern of 35 cm x 35 cm.

This research was to investigate the response of rice on some principle concepts of SRI, those are age of seedlings and plant spacing which may be applied by farmers.

MATERIALS AND METHODS

Site and time: The experiment was conducted in October 2014 until January 2015, at Pasar Melintang Village, Deli Serdang regency, North Sumatra, Indonesia, with elevation of 26 m above sea level, wet tropical climate, soil texture sandy loam with pH 5.6.

Experimental design: Experiments were conducted in a randomized block design with factorial with three replications. The treatments consisted of combination of four different plant spacings [J1 (25 cm x 25 cm), J2 (30 cm x 30 cm), J3 (35 cm x 35 cm) and J4 (40 cm x 40 cm)] and two ages of seedlings [A1(8 days old), A2 (12 days old).

Materials: paddy rice (*Oryza sativa* L.) Variety Ciherang, compost, Urea, N P K Mutiara, SP-36 and KCL. Pesticides: insecticides (Bestox 50 EC and Hamasid 25 EC), Fungicide (Sorento and Dennis 75 WP), molluscicide (Besnoit).

Tools: meter, hoe, harrow, hand sprinkler, ruler, bucket, analytical scale Ohaus (0.001 g), pencil, pen, and logbook.

Land preparation**:** Compost was spread over the land as much as 1,250 kg·ha^{-1} before plowing. The soil was plowed as deep as 30 cm and buried residual plants on the land, then the soil was crumbed with harrow, then was leveled. The trenches were made around the whole land and around each plot, to maintain aerob condition wherever possible.

Nursery preparation: The nursery was prepared on seedbed with 1.5 m x 2.0 m, in the main research land. Soil was plowed as deep as 30 cm and buried residual plants on the land, then the soil was crumbed, with harrow, then was leveled. The trenches were made around the seedbed, to avoid over irrigated. Before the seeds were sown, beds firstly was sown with compost as much as 30 kg. Seedbed then was sprayed with molluscicide, Besnoit.

Seed preparation: The seeds were soaked in a bucket filled with water until all the seeds were submerged. The seeds that float were discarded, and the seeds that sink were soaked for 12 h and incubated in moist gunny suck for 24 h to accelerate germination. Germinated seeds then were sown on the surface of the seedbeds, then covered with a thin layer of soil.

Transplanting: Before transplanting, firstly plant spacings were drawn for each plot as treatment accordingly. One seedling per hole was planted with 1-1.5 cm depth, and aerob condition.

Fertilization: Broadcasting of fertilization was applied twice, firstly, when the plant age 10 DAP with urea 60 kg·ha^{-1}, N P K Mutiara 30 kg·ha^{-1} and SP-36 30 kg·ha^{-1}. Secondly, when plant age 25 DAP with 30 kg Urea·ha^{-1}, KCl 60 kg·ha^{-1}, SP-36 90 kg·ha^{-1} and NPK Mutiara 30 kg·ha^{-1}. Irrigation, was maintained moist.

Pest and disease control: Pest and disease was controlled by spraying insecticides and fungicides. Insecticide used was BESTOX, Hamasid 50 EC and 25 EC. Fungicides used were Sorento and Dennis 75 WP.

Measurement of parameters: Before conducting measurements of parameters, firstly it was determined 1m^2 the most homogeneous growth from each treatment plot as samples from each treatment plot. Of 1 m^2 was determined three clumps for measurements of parameters. Plant height was measured from ground level to the highest leaves by using meter rolls. Measurements were made per 10 DAP (Day After Planting) for 60 days. Number tillers was conducted at harvest. Stem diameter was measured at the end of the observation by using vernier calipers. Stem diameter of three plants from each clumb was measured. Measurements were taken at the third segment of each stem. Panicle length was measured from 3 stalks of each sample clump. Number of grain per panicle was derived from 3 stalks of each three clumbs. Number of filled grains per panicle was derived from 3 plants from each 3 clumbs. Yield was measured by harvesting the three sample plots, then it wasaveraged then converted into ton·ha^{-1}. Dry weight of 1000 grains was measured by picking up 1000 filled grains from the yield by hand, then dried under the sun light until water content 16%, then weight by using analytical scale.

RESULTS AND DISCUSSION

Results of the study regarding the influence of age of seedling and plant spacing and their interactions on growth and yield of rice variety Ciherang presented in Tab. 1, 2 and 3 as well as Fig. 1,2, 3, 4 and 5.

Effect of Age of Seedlings.

This research result showed there was no significantly different of growth and yield of rice between transplanted seedling age of 8 days old and 12 days old. (Tab. 1 and 2), These results correspond with the results of the research of SEMBIRING ET AL. (2003). However, this result was different from research conducted by NAIDU1 ET AL. (2013) where they found that planting of 12 days old seedlings resulted in the highest grain yield compared with 8 days old seedlings. This difference result might due to different enviroment and cultivars used.

Effect of plant spacing:

Number of tillers: As the plant spacing increased the larger the number of tillers. The highest number tillers was resulted upon plant spacing 40 cm x 40 cm and was very significantly diferrent from three other plant spacings (Tab. 3). The correlation between plant spacings and number of tillers was linearly positive, and was very significant, with co-efficient of determination (R^2=0.978) (Fig. 1) indicating that 97.8% of the total variation of number of tiller could be attributed to the plant spacing treatment alone and 2.2% by other factors were not investigated.

Tab. 1. – The effect of plant spacing and seedling age on height at 60 DAP

Seedling age (day)	Height of paddy rice at 60 DAP (cm)				
	Plant spacing (cm)				
	J1 (25x25)	J2(30x30)	J3 (35x35)	J4 (40x40)	Average
U1 (8 days)	112.0	110.6	109.2	110.4	110.5
U2 (12 days)	108.3	110.9	112.6	110.9	110.67
Average	110.15	110.75	110.9	110.65	n.s

DAP : Day after planting. n.s: non significant

Tab. 2. – The effect of seedling age on growth and yield of paddy rice at 100 DAP

Seedling age (day)	Number of tillers	Stem diameter (cm)	Panicle length (cm)	Number of grain per panicle	Number of filled grain per panicle	weight of 1000 dry grain (g)	Yield (ton·ha^{-1})
U1 (8)	21.93	0.59	27.18	205.18	189.39	43.18	5.26
U2 (12)	21.21	0.55	26.59	204.75	188.68	43.57	5.07
	n.s	n.s	n.s	n.s	n.s	n.s	n.s

DAP : Day after planting

Tab. 3. – The effect of plant spacing on growth and yield of rice at 100 DAP

Plant spacing (cm)	Number of tillers	Stem diameter (cm)	Panicle length (cm)	Number of grain per panicle	Number of filled grain per panicle	weight of 1000 dry grain (g)	Yield (ton·ha^{-1})
J1(25 x 25)	15.27aA	0.58	26.64aAB	195.03aA	180.78aA	43.05	5.995cB
J2(30 x30)	18.77 bAB	0.57	27.05abAB	204.91aAB	188.46aAB	43.32	5.01bB
J3(35 x 35)	22.88 cB	0.55	26.14aA	199.33aA	185.95aAB	43.43	6.095cB
J4(40 x 40)	29.38dC	0.57	29.38dC	220.41bB	200.96bB	43.71	3.465aA
		n.s				n.s	

Figures followed by the same letter on the same column showed no significant effect on the level of α = 0.05(lowercase) and α = 0.01 (uppercase) by Duncan. DAP : Day after planting

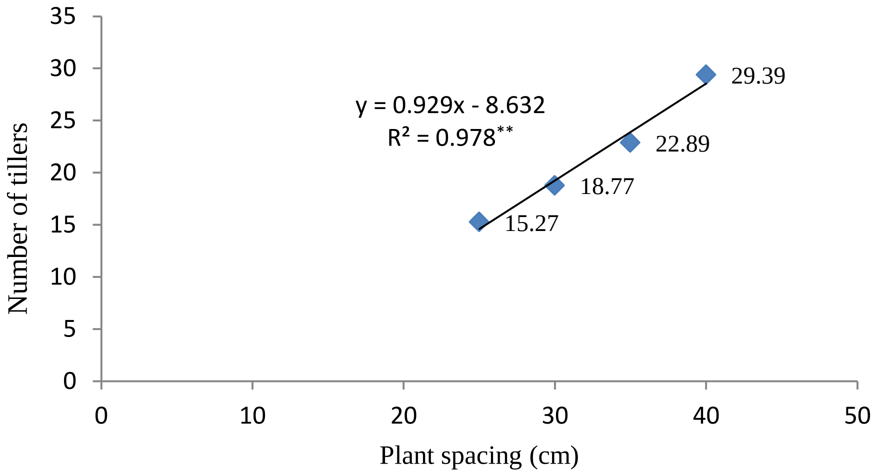

Fig. 1. – Correlation between plant spacing and number of tiller

Stem diameter: Final measurement of stem diameter was 60 DAP, for the generative growth was started at 60 DAP. The results showed that there was no significantly different of stem diameter among plant spacing tested (Tab. 1). This due to that the closet plant spacing J1 (25 cm x 25 cm) had might had reached the maximum of stem diameter of rice namely 0.55 cm this result supported BY PASARIBU ET AL., (2013) that recorded that stem diameter of rice Ciherang was less than 0.5 cm.

Panicle length: Plant spacing of 40 cm x 40 cm resulted the longest panicle and was very significantly different from three other plant spacings ($p<0.01$). While the other three plant spacings were not significantly different ($p>0.05$) (Tab. 3). This results agreed with the research result conducted by SALAHUDDIN ET AL. (2009) where they found that plant spacing did affect panicle length of aman rice. There was a quadratic correlation between plant spacing and panicle length with co-efficient of determination (R^2=0.455) and was significant. indicating that 45,5 % of the total variation of panicle length could be attributed to the plant spacing treatment alone and 54.5% by other factors were not investigated.

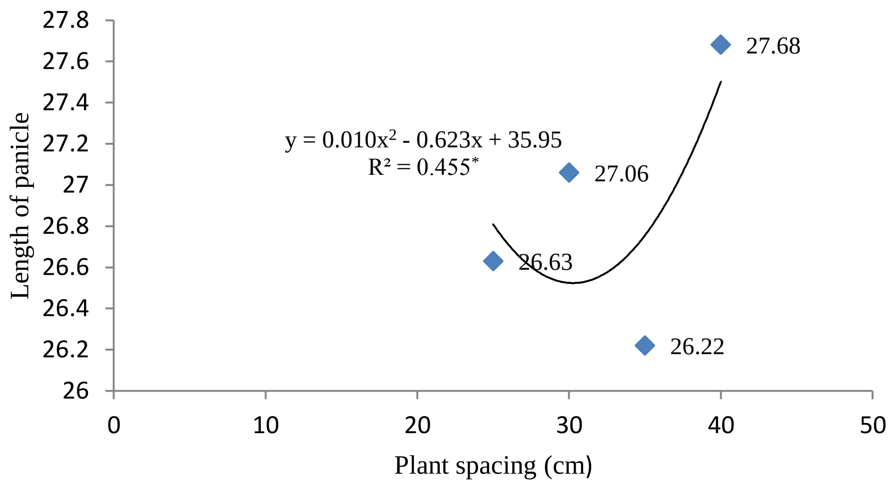

Fig. 2. – Correlation between panicle length and plant spacing

Number of grain per panicle: Plant spacing of 40 cm x 40 cm resulted the highest number of grain per panicle, and it was very significantly different from plant spacing of 25 cm x 25 cm and 30 cm x 30 cm ($p<0.01$) and significantly different from plant spacing of 30 cm x 30 cm ($p<0.05$) (Tab. 3). This results agreed with the research result conducted by Salahuddin, et al.(2009) where they found that plant spacing did affect number of grain per panicle of aman rice. The correlation between plant spacing and number of grain per panicle was very significant linear positive with co-efficient of determination ($R^2=0.671$) (Fig. 3). This indicated that plant spacing alone could be attributed 67% upon the total variation of number of grain per panicle and about 37% was due to other factors were not observed.

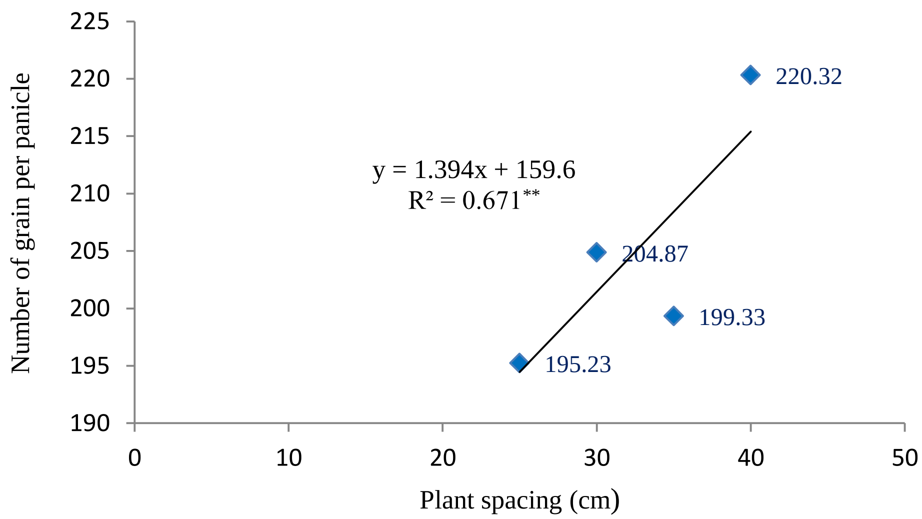

Fig. 3. – Correlation between number of grain per panicle and plant spacing

Number of filled grain per panicle: Plant spacing of 40 cm x 40 cm resulted the highest number of filled grain per panicle, and it was significantly different from three other plant spacings ($p<0.05$) and was very significantly different from plant spacing of 25 cm x 25 cm ($p<0.01$) (Tab. 3). The correlation between plant spacing and number of filled grain was very significantly linear positive ($p<0.01$) with co-efficient of determination ($R^2=0.764$) (Fig. 4). This indicated that plant spacing alone could be attributed 76.4% on total variation of filled grain was contributed due to plant spacing.

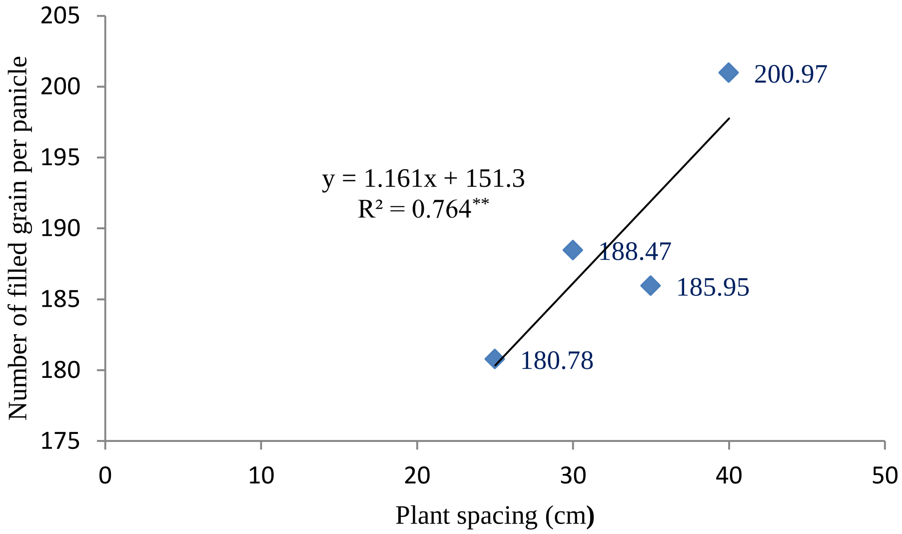

Fig. 4. – Correlation between plant spacing and number of filled grain per panicle

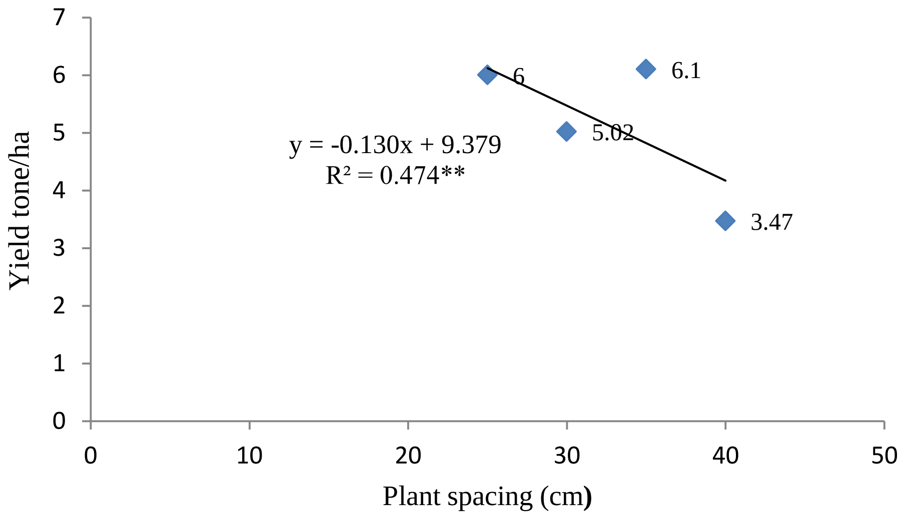

Fig. 5. – Correlation between plant spacing and yield (ton·ha^{-1})

Weight of 1000 dry grain: There was no effect of plant spacing on weight of 1000 dried grain. This might be for the closet plant spacing had reached the maximum weight of 1000 dry grain, this suggestion was supported by the description of rice Ciherang that the weight of 1000 grain of rice Ciherang was 27 – 28 g (Balai Besar Penelitian Tanaman Padi, 2016).

Yield: plant spacing did affect significantly yield, this result was supported by SALAHUDDIN, ET AL. (2009) and Naidu1 et al.(2013). The highest grain yield was produced with plant spacing of 35 x 35 cm (J3), and was significant different from plant spacing fo 30 cm x 30 cm (J2) and 40 cm x 40 cm (J4) ($p<0.05$), but was not significantly different from plant spacing of 25cm x 25 cm (J1) ($p<0.05$). The correlation between plant spacing and yield was very significantly linear negative ($p<0.01$) with co-efficient of determination (R^2=0.474) (Fig. 5). This indicated that plant spacing alone could be attributed 47.4% on total variation of yield and 52.6% was due to other factors were not observed. This results was similar to the results of research conducted BY PANDIANGAN, ET AL. (2014) where plant spacing of 35 cm x 35 cm resulted the highest yield compared with 25 cm x 25 cm, 30 cm x 30 cm and 40 cm x 40 cm on rice cultivar IR 64. The lowest yield was recorded with the plant spacing of 40 cm x 40 cm (J4) (Tab. 3). This results was different from result found by NAIDU1 ET AL. (2013) where plant spacing of 25 cm x 25 cm resulted the highest yield compared with plant spacings of 20 cm x

20 cm, 30 cm x 30 cm and 35 cm x 35 cm. They found that plant spacing of 35cm x 35 cm resulted the lowest yield. This might be due to different variety used. Plant spacing of 40 cm x 40 cm resulted the lowest yield, whereas, it resulted the highest on other growth parameters, that logically would resulted the highest yield as well. The lowest yield resulted from plant spacing of 40 cm x 40 cm might be due to the number of population per ha much lower than population of other plant spacings. The number of clumps per hectar of plant spacing 40 cm x 40 cm was 62,522 clumps compared with the number of clumps per hectar of plant spacing 35 cm x 35 cm was 81,632 clumps.

CONCLUSIONS

The result of the study realized that age of seedlings between 8 and 12 days old did not affect growth and yield, plant spacing did affect yield, number of tillers, length of panicle, number of grain per panicle, but did not affect plant height, stem diameter and weight of 1000 dry grain, plant spacing of 35 cm x 35 cm resulted the highest yield, there was no interaction between plant spacing and age of seedlings on growth and yield.

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