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Influence of steckling transplanting date and steckling size on seed production of radish (*Raphanus sativus* L.) var. beeralu under Mid and Up Country Wet Zone of Sri Lanka

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Abstract

Field experiments were conducted at two locations representing Mid Country Wet Zone and Up Country Wet Zone to find out the impact of steckling transplanting time steckling size and location on seed production of Beeralu radish. Pre mature bolting occurred at Sita Eliya (WU2b) during both seasons restricting the imperative selection of true to type stecklings in root to seed method. Transplanting large (14-17 cm) and medium (11-13 cm) stecklings before mid July during *Yala* and before the end of December during *Maha* significantly increased (p<0.05) seed yield and quality over the small stecklings (7-10 cm) at Gannoruwa (WM2b). Seed yield and quality increased significantly (p<0.05) in *Yala* over *Maha* at Gannoruwa. Sita Eliya crop raised using the roots of Gannoruwa crops just for one transplanting date of *Maha*, confirmed the superiority of large and medium stecklings. Seed yield and quality were significantly higher (p<0.05) in Sita Eliya over Gannoruwa revealing the best conditions for seed production present under the low temperature conditions at Sita Eliya. Root production was impossible in Sita Eliya due to pre mature bolting occurred under low temperature conditions. This study reveal that transplanting true to type, more than 10 cm long stecklings, in Sita Eliya under poly tunnels or maintaining proper isolation to avoid out crossing is an appropriate method in quality seed production of Beeralu radish.

Keywords: Radish, Seed production, Steckling size, Transplanting date

Introduction

Radish crop is popular among farmers and home gardeners all over the country, because of its fast growing, short duration, low input cropping nature and high medicinal value. Both leaves and roots are edible and rich in minerals, vitamin C and radish consumption is believed to be good for the liver, stomach, kidneys and urinary system. Radish enzyme extract can significantly diminish hepatic damage (Lee *et al*., 2012).

Farmers cultivate radish crop in between other crops throughout the year and also it has a real advantage in using between two cropping seasons as off-season cultivation. Soil rehabilitation in high intensity cropping fields, pest and disease control are some of the added advantages that the farmers can obtain by radish cultivation. Radish can escape from holoparasitic plant Cuscuta while almost all the other local vegetable crops are vulnerable to Cuscuta attack (Pradeepika *et al*., 2006; Jayakody *et al*., 2007).

Although our local varieties Beeralu and Ball radishes have good yield potential, adaptability and consumer preference, seed importation data reveals that the majority of the national seed demand of the country is fulfilled by exotic varieties every year. Total extent under radish cultivation is around 3000 ha per year. Accordingly, the national seed requirement of radish is around 12,000 kg per year. According to the seed importation data of previous four years, 10,000 - 11,000 kg of radish seeds were imported every year and the minor balance is supplied by formal and informal systems revealing the unfortunate situation of local radish seed production. Lack of awareness on seed production technology of radish and information gap on the seed production techniques of radish under local conditions are some critical reasons which have been made the situation more terrible. Imported radish varieties do not set seeds under local conditions and seed production of two radish varieties recommended and released (Lanka Ball and Beeralu) by the Department of Agriculture (DoA) is practiced in Sri Lanka.

Radish seed production can be employed either by "seed to seed method "or" root to seed method ". " Root to seed method" allows to select true-to-type, healthy roots to produce genetically pure, high seed yield with high quality, and therefore, this method is recommended to produce higher seed categories. Seed certification guidelines of Sri Lanka (Seed Certification Hand Book Part II, 1983), clearly point out the acceptable range for root shape but no evidence regarding the root size which can be used to produce good seed yield with high quality. In the prebasic and basic seed production, it is needed to explore the optimum size of the stecklings for transplanting. Findings of Dev (2010),

Hamid *et al*. (2002) and Kumar *et al*. (2012) have revealed that the effect of steckling size on seed production of radish. Some countries, especially in Asia, up to half of the each root is removed before replanting and increased seed yield of Japanese white cultivars has been reported through practicing this method (Jandial *et al*.,1997).

In the "root to seed method", replanting of roots using wider spacing is practiced, however no research evidence to use the most appropriate spacing for our local varieties under local conditions. Kaushal and Sharma (2003) have found that different sowing dates, transplanting dates of stecklings and plant spacing remarkably influenced various growth characters and seed yield of radish. It is very difficult to raise good quality radish roots because of excessive forking, splitting, cracking and pithiness, which could be highly influenced by spacing and time of sowing (Lavanya *et al*.,2012).

As information on the seed production techniques of radish is very rare under local conditions, it is important to create farmer preference to locally produced radish seeds and promote radish seed production via introducing a proper seed production package to produce high quality seeds and it would also minimize theseed importation which arises problems in introducing alien pests as contaminants. This experiment was planned to explore some of the critical points of radish seed production to introduce improved mechanism for increase seed yield and quality of Beeralu radish by investigating the effect of steckling transplanting date and steckling size on growth of seed crop, flowering, seed yield and seed quality under Mid Country Wet Zone and Up Country Wet Zone.

Materials and Methods

Field experiments were carried out at two locations representing Mid Country Wet Zone at post control field of Seed Certification Service (SCS), Gannoruwa (WM2b) and Up Country Wet Zone at post control field of SCS, Sita Eliya (WU2b) during two consecutive seasons 2014 *Yala* and, 2014/15 *Maha*.

The field trials conducted in two steps; 1st step was sowing seeds to produce mother roots/stecklings and 2nd step was transplanting of stecklings to raise the seed production crops. The crop management was done according to DoA recommendations. Laboratory tests were conducted in the Central Seed Testing Laboratory of Seed Certification Service, Peradeniya.

Mother root/steckling production step

Seed sowing was practiced in five sowing dates in both seasons at both locations maintaining 15 days interval between two sowing dates starting from 30th April 2014 to 30th June 2014 in *Yala* and from 20th October 2014 to 20th December 2014 in *Maha*. Crop

destroyed due to bad weather during 3rd sowing date of *Maha*.

Seed material used for this research work was a breeder seed lot of variety Beeralu and the field emergence of seeds was above 90% at both locations in both seasons. DoA fertilizer recommendation along with the well decayed cow dung were used. Whole crop of each sowing date was uprooted within 40-45 days after sowing or at the time of bolting initiation, if the crop started bolting before 40 days. If the crop started initiating bolting before 40 days, uprooting practiced just appearing around five seed stalks in the crop.

Seed production step

The diameter of the truetotype roots of Beeralu radish is proportionately change with the length of the root. Therefore, three groups of steckling sizes in length; large (14-17 cm), medium (11-13 cm) and small (7-10 cm) were selected and replanted using 45 × 45 cm^2 spacing in 2 × 1.1 m^2 size plots at the rate of 15 stecklings per plot. Leaves were cut down leaving around two or three inches at the base of the leaves before replanting. Since there is no local fertilizer recommendation at replanting of radish stecklings, well decayed cow dung (20×20×10 cm^3 volume per hill) was added to each hill before replanting. Each plot consisted of 15 plants and replicating three times for each steckling size, nine plots were maintained.

Five transplanting dates starting from 07th June 2014 to 08th August 2014 during *Yala* and from 04th December 2014 to 01st February 2015 during *Maha* were practiced according to the uprooting of each crop during both seasons.

Collection of experimental data

Observations on growth and yield parameters were done using randomly selected five well grown plants in each replicate. Height of the inflorescence (cm) and number of primary branches in the inflorescence at full blossoming stage were taken as growth parameters of the seed crop. Number of pods per plant, seed yield per plant (g), seed yield per plot (g) and seed yield per ha (kg) were considered as seed yield parameters. Seed yield per hectare was calculated extrapolating the seed yield per plot. Observations on seed yield parameters were recorded from processed, dried and well cleaned seeds at 7% seed moisture level.

Seed quality parameters considered in this experiment were 1000 seed weight (g) at 7% seed moisture level, seed germination%, seedling shoot and root length (cm) at the final date of germination count, and seed vigour index as illustrated by Gupta (1993) referring the method prescribed by Abdul-Baki and Anderson (1973). The seed vigour index was

determined by multiplying the percentage germination with the seedling length. Germination test was conducted according to the stipulated method of International Seed Testing Association (ISTA, 2007). Between paper (BP) method was used to 50 × 4 seeds and allowed to germinate inside a germinator.

Alteration to the initial experimental plan

Due to premature bolting around 15 days after sowing in Sita Eliya (WU) location, without forming swollen roots during both seasons, excess roots of three sizes (14-17 cm, 11-13 cm and 7-10 cm) selected from Gannoruwa location were transplanted in Sita Eliya in the 2nd season just for one transplanting date and the growth, yield and quality data were collected according to the same above manner.

Statistical design and data analysis

Statistical design was randomized complete block design, replicated three times with factorial concept. The data were statistically analyzed and subjected to the analysis of variance using SAS (Version). Mean separation was done according to the Duncan Multiple Range Test. All the statistical analysis for percentage values were done after converting in to square root values.

Pre-mature bolting occurred in Sita Eliya location during both seasons leaving gaps in data of one location. Gannoruwa data were analyzed using a three factor factorial design where season, steckling transplanting date (TPD) and steckling size were the factors. Data of the 1st transplanting date of *Maha*, Gannoruwa were analyzed with the data of Sita Eliya crop raised on the same day using the stecklings produced at Gannoruwa according to a two factor factorial design where location and steckling size were the factors.

Results and Discussion

Growth parameters of the Gannoruwa (WM2b) seed crops

No interaction effect was significant on inflorescence height ($p>0.05$), but two-way interactions between seasonxsteck. size, seasonxsteck. transplanting date (TPD) and TPD xsteck size were significant with respect to number of primary branches in the inflorescence ($p<0.05$). According to Table 1, significantly higher inflorescence height recorded in *Yala* over *Maha*. Inflorescence height of the crops raised using large and medium stecklings was significantly higher over small stecklings. Transplanting of stecklings before end of July in *Yala* and before end of January in *Maha* has significant positive effect on inflorescence height.

Table 1. Effect of steckling transplanting date, steckling size and cropping season on inflorescence height of Beeralu radish at Gannoruwa (WM2b)

Factor		Inflorescence height (cm)
Season	2014 *Yala*	95.28[a]
	2014/15 *Maha*	91.95[b]
Steckling size	Large (14-17 cm)	99.81[a]
	Medium (11-13 cm)	100.12[a]
	Small (7-10 cm)	81.47[b]
Steckling transplanting date (TPD)	TPD 1 (*Yala*-07.06.2014, *Maha*- 04.12.2014)	95.71[ab]
	TPD 2 (*Yala*-21.06.2014, *Maha*-04.12.2014)	96.04[ab]
	TPD 3 (*Yala*-07.07.2014) 97.93[a]	
	TPD 4 (*Yala*-22.07.2014, *Maha*-18.01.2015)	93.14[b]
	TPD 5 (*Yala*-08.08.2014, *Maha*-01.02.2015)	88.23[c]
CV%		4.76

Means withsimilar lettersforfactorare statistically non-significant at 5% level of probability (DNMRT test).

According to Table 2, seed crops established using large and medium stecklings in *Yala* produced significantly higher (p<0.05) number of primary branches. Though there was no difference among five transplanting dates of *Yala*, it showed significant increase (p<0.05) in transplanting stecklings before mid January during *Maha* with respect to the number of primary branches (Table 2).

Table 2. Effect of steckling transplanting date, steckling size and cropping season on number of primary branches in the inflorescence of Beeralu radish at Gannoruwa (WM2b)

Factor		Number of primary branches in the inflorescence	
		2014 *Yala*	**2014/15 *Maha***
Steckling size	Large	12.67[a]	12.82[a]
	Medium	12.64[a]	12.65[a]
	Small	12.01[b]	11.43[b]
CV%	2.02	12.44[x]	12.30[y]
Steckling transplanting date (TPD)	TPD 1	12.51[a]	12.49[a]
	TPD 2	12.42[a]	12.47[a]
	TPD 3	12.27[a]	*
	TPD 4	12.49[a]	12.16[b]
	TPD 5	12.51[a]	12.09[b]
CV%		2.41	2.49

Means with similar letterswithin the column for each factorand within the row for seasons are statisticallynonsignificant at 5% level of probability (DNMRT test).

High performance in seed crop growth of large and medium size stecklings may be due to the nutritional support given by high amount of stored food content in large and medium size stecklings than small size stecklings for seed crop development. These results are almost in parity with Dev (2010) who reported higher seed plant height and more number of branches per plant from bigger size stecklings. Singh *et al*. (1990) have also noted greater primary and secondary branches per plant with larger steckling size in radish.

Higher seed crop growth in *Yala* than *Maha* may be due to negative impact of the fluctuations in average maximum environmental temperature (Figure 1) and high intensity rainfall events during *Maha* (Figure 2) on seed crop growth of Beeralu radish. Stable maximum environmental temperature variance and congenial moisture status in soil with low rainfall incidences may be beneficial in proper establishment of stecklings and better growth to form higher inflorescences in early transplanting, before end of July in *Yala*.

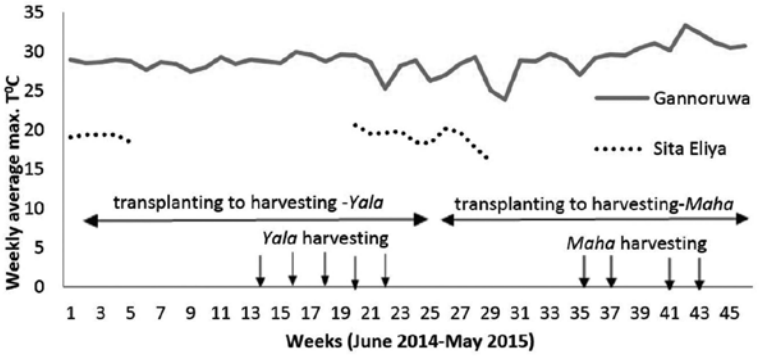

Figure 1. Weekly average maximum temperature (°C) at Gannoruwa location from transplanting to seed harvesting in 2014 *Yala* and 2014/15 *Maha*

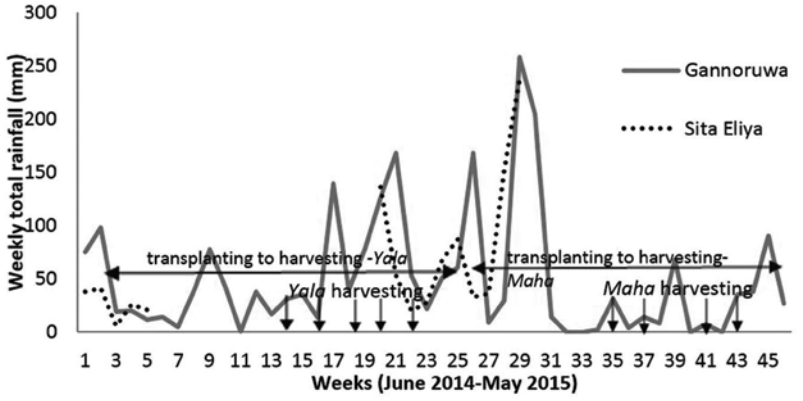

Figure 2. Weekly total rain fall (mm) at Gannoruwa location from transplanting to seed harvesting in 2014 *Yala* and 2014/15 *Maha*

Though the results did not reveal the impact of transplanting dates of *Yala* on number of primary branches, Malik *et al*.(1999), have recorded, maximum seed plant height and more number of branches per plant of radish in early planting dates.

Seed yield parameters of the Gannoruwa (WM2b) seed crops

No interaction effects were significant (p>0.05) on seed yield per plant, seed yield per plot and seed yield per hectare (Table 3), but two-way interactions between season x steckling size and TPD x steckling size were significant (p<0.05) with respect to the number of pods per plant (Table 4). According to Table 3, seed yield per plant, seed yield per plot and seed yield per hectare were significantly higher in *Yala* over *Maha* and in crops of large and medium stecklings over small stecklings.

Transplanting of stecklings before mid July in *Yala* and before mid January in *Maha* showed significant positive impact on three seed yield parameters (Table 3). Fluctuations in diurnal temperature (Figure 1) and rainfall pattern with high intensity rainfall events (Figure 2) recorded during *Maha* followed by low seed crop growth may be the reason for low performance in seed yield parameters of Beeralu radish during *Maha*.

Table 3. Effect of steckling transplanting date, steckling size and cropping season on seed yield of Beeralu radish at *Gannoruwa* (WM2b)

Factor		Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Seed yield ha^{-1} (kg)
Season	2014 *Yala*	17.4^{a}	194.9^{a}	802.1^{a}
	2014/15 *Maha*	15.5^{b}	171.6^{b}	706.1^{b}
Steckling size	Large	18.4^{a}	205.9^{a}	847.5^{a}
	Medium	18.4^{a}	208.0^{a}	855.9^{a}
	Small	12.8b	139.7^{b}	575.0^{b}
Steckling transplanting date (TPD)	TPD 1	17.0^{a}	189.8^{a}	780.9^{a}
	TPD 2	17.2^{a}	192.7^{a}	793.1^{a}
	TPD 3	17.5^{a}	195.7^{a}	805.6^{a}
	TPD 4	15.8^{b}	175.9^{b}	723.7^{b}
	TPD 5	15.6^{b}	174.2^{b}	716.9^{b}
CV%		3.84	4.44	4.43

Means with similar lettersfor each factor are statistically non-significant at 5% level of probability (DNMRT test)

According to Table 4, crops raised using large and medium stecklings in *Yala*, and transplanting before mid July in *Yala* and up to mid January in *Maha* showed significant increase in number of pods per plant.

Table 4. Effect of steckling transplanting date, steckling size and cropping season on number of pods per plant of Beeralu radish at Gannoruwa (WM2b)

Factor		Number of pods per plant	
		2014 *Yala*	**2014/15 *Maha***
Steckling size	Large	572.8[a]	486.6[a]
	Medium	577.8[a]	478.8[a]
	Small	314.3[b]	268.0[b]
CV%	4.88	488.3[x]	411.2[y]
Steckling transplanting date (TPD)	TPD 1	504.5[a]	419.9[a]
	TPD 2	511.9[a]	424.7[a]
	TPD 3	498.4[a]	*
	TPD 4	463.6[b]	412.9[a]
	TPD 5	463.2[b]	387.1[b]
CV%		5.43	5.72

Means with similar letterswithin the column for each factor and within the row for seasons are statistically non-significant at 5% level of probability (DNMRT test)

This could be due to taller inflorescences with more number of primary branches being more conspicuous, receiving more pollinator visits and thereby receiving more pollen than smaller and lower inflorescences or to patterns of resource allocation within plants (Graham, 1981). Hamid *et al*. (2002) have also recorded the formation of highest number of pods per plant and greater seed yield per hectare by plants of larger root size of radish.

Reduction in seed yield parameters under delayed transplanting might be due to the bad effect of high rainfall events (Figure 2) during seed maturity and harvesting stage of both seasons. Kaushal and Sharma (2003) have observed the maximum number of pods per plant, weight of pods per plant, seed yield per plant and 1000 seed weight from 1st transplanting date over other transplanting dates of steckilngs.

Seed quality parameters of the Gannoruwa (WM2b) seed crops

Season x TPD interaction was significant (p<0.05) on seed germination percentage, seedling root length and seedling shoot length while season x steckling size interaction was significant (p<0.05) on 1000 seed weight (Table 5, 6). No interaction effects were significant (p>0.05) on seed vigour index (Table 7).

According to Table 5 and 6, crops from large and medium stecklings in *Yala*, produced seeds with significantly higher 1000 seed weight, seedling root length and seedling shoot length while no significant impact of steckling size on seed germination.

Table 5. Effect of steckling transplanting date, steckling size and cropping season on 1000 seed weight and seed germination% of Beeralu radish at Gannoruwa (WM2b)

Factor		1000 seed weight (g)		Seed germination (%)	
		2014 *Yala*	**2014/15 *Maha***	**2014 *Yala***	**2014/15 *Maha***
Steckling size	Large	11.4[a]	11.1[a]	84[a]	82[a]
	Medium	11.4[a]	11.2[a]	85[a]	82[a]
	Small	10.9[b]	10.4[b]	83[a]	81[a]
		11.23x	10.9y (CV% = 1.68)	84x	81.6y (CV%=1.96)
Steckling transplanting date (TPD)	TPD 1	11.3[a]	11.0[a]	87[a]	81[a]
	TPD 2	11.3[a]	11.1[a]	85[ab]	82[a]
	TPD 3	11.3[a]	*	84[bc]	*
	TPD 4	11.2[a]	10.8[b]	82[c]	82[a]
	TPD 5	10.9[b]	10.6[c]	81[c]	81[a]
CV%	1.74	1.48	1.97	1.50	

Means with similar letterswithin the column for each factor and within the row for seasons are statistically non-significant at 5% level of probability (DNMRT test)

Table 6. Effect of steckling transplanting date, steckling size and cropping season on seedling root length (cm) and seedling shoot length (cm) of Beeralu radish at Gannoruwa (WM2b)

Factor		Seedling root length (cm)		Seedling shoot length (cm)	
		2014 *Yala*	**2014/15 *Maha***	**2014 *Yala***	**2014/15 *Maha***
Steckling size	Large	13[a]	12[a]	6.98[a]	6.78[a]
	Medium	13[a]	12[a]	6.99[a]	6.70[a]
	Small	12[b]	11[b]	6.02[b]	5.97[b]
CV%		12.56[x]	12.1[y]	6.6[x]	6.4[y]
			1.81		2.82
Steckling transplanting date (TPD)	TPD 1	13.1[a]	12.2[a]	6.74[ab]	6.73[a]
	TPD 2	12.7[b]	12.3[a]	6.62[bc]	6.60[a]
	TPD 3	12.6[b]	*	6.77[a]	*
	TPD 4	12.2[c]	12.1[ab]	6.63[abc]	6.34[b]
	TPD 5	12.1[c]	11.9[b]	6.55[c]	6.27[b]
CV%		2.01	1.49	2.14	3.40

Means with similar letters within the column for each factor and within the row for seasons are statistically non-significant at 5% level of probability (DNMRT test)

Transplanting before end of July in *Yala*, and before mid January in *Maha* recorded significantly higher 1000 seed weight while seed germination % in *Yala* showed significant increase over *Maha* (Table 5). Transplanting before mid July in *Yala* showed significant increase in seed germination % while no significant impact of steckling transplanting dates on seed germination during *Maha* (Table 5).

Seedling root and shoot lengths showed irregular relationship on transplanting dates, however, raising of crops before end of July in *Yala* and before mid of January in *Maha* showed significant increase in root and shoot lengths (Table 6).

According to Table 7, significantly higher Seed Vigour Index (SVI) recorded in *Yala* over *Maha*, large and medium stecklings over small stecklings. Transplanting before mid July in *Yala* and before the end of December in *Maha* showed significant increase in SVI.

Better seed crop growth with more stored food allocations might have again resulted in better development of seeds with high quality produced by large and medium stecklings over small stecklings. Dev (2010) has also reported, non-significant differences for 1000 seed weight and seed germination% by the root size of radish. Contrary to those findings, according to the Malek *et al*. (2012), carrot seeds produced by high weight stecklings have recorded significantly superior performance in 1000 seed weight, seed germination% and seed vigour index.

High intensity rainfall events and fluctuating pattern in temperature during *Maha* (Figure 1, 2) followed by low seed crop development might be resulted in low seed quality. Seed quality parameters showed significantly better performance in early transplanting of stecklings for seed production of Beeralu radish (Table 5-7) and it again might be the reason of high rainfall incidences during seed maturity and harvesting stage of late transplanting crops.

Table 7. Effect of steckling transplanting date, steckling size and cropping season on seed vigour index of Beeralu radish at Gannoruwa (WM2b)

Factor		Seed Vigour Index (SVI)
Season	2014 *Yala*	560.6[a]
	2014/15 *Maha*	525.6[b]
Steckling size	Large	571.5[a]
	Medium	574.6[a]
	Small	489.0[b]
Steckling transplanting date (TPD)	TPD 1	563.7[a]
	TPD 2	553.3[a]
	TPD 3	568.7[a]
	TPD 4	531.4[b]
	TPD 5	519.8[b]
CV%		4.55

Means with similar letters for each factor are statistically non-significant at 5% level of probability (DNMRT test)

Growth and yield parameters at Gannoruwa (WM2b) and Sita Eliya (WU2b)

No interaction effects were significant (p>0.05) on growth and seed yield parameters. Significantly higher number of branches in the inflorescence, number of pods per plant, seed yield per plant, seed yield per plot and seed yield per hectare recorded in Sita Eliya over Gannoruwa, while no significant impact of location on inflorescence height (Table 8, 9). Significantly higher inflorescence with higher number of primary branches, number of pods per plant, seed yield per plant, seed yield per plot and seed yield per hectare (Table 8, 9) recorded with large and medium stecklings over small stecklings.

Table 8. Effect of steckling size and cropping location on inflorescence height and number of primary branches in the inflorescence of Beeralu radish in 2014/15 *Maha*

Factor		Inflorescence height (cm)	Number of primary branches in the inflorescence
Location	Gannoruwa (WM)	94.9[a]	12.5[b]
	Sita Eliya (WU)	94.3[a]	13.4[a]
Steckling size	Large	100.8[a]	13.6[a]
	Medium	101.5[a]	13.5[a]
	Small	81.7[b]	11.7[b]
CV%		3.06	1.94

Means with similar letters for each factor are statistically non-significant at 5% level of probability (DNMRT test)

Table 9. Effect of steckling size and cropping location on number of pods per plant, seed yield per plant, seed yield per plot and seed yield per hectare of Beeralu radish in 2014/15 *Maha*

Factor		Number of pods plant^{-1}	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Seed yield (kg ha^{-1})
Location	Sita Eliya (WU)	813.2[a]	25.5[a]	292.1[a]	1201.8[a]
	Gannoruwa (WM)	419.9[b]	16.1[b]	179.1[b]	736.9[b]
Steckling size	Large	705.8[a]	23.3[a]	265.0[a]	1090.3[a]
	Medium	701.2[a]	23.3[a]	265.8[a]	1093.7[a]
	Small	442.6[b]	15.8[b]	176.0[b]	724.0[b]
CV%		5.78	9.01	10.87	10.86

Means with similar letters within a column for each factor are statistically non-significant at 5% level of probability (DNMRT test)

Seed quality parameters of the Gannoruwa (WM2b) and Sita Eliya (WU2b) seed crops

Interaction effects were non-significant (p>0.05) on 1000 seed weight, seed germination%, seed vigour index and seedling shoot length due to location and steckling size. A significant interaction due to location and steckling size was found with respect to the seedling root length (Table 11).

Table 10 shows significant increase in 1000 seed weight, seed germination%, seed vigour index and seedling shoot length at Sita Eliya (WU2b) crops over Gannoruwa (WM2b) crops. Seeds produced from large and medium stecklings showed significantly higher seed weight, seed vigour index and seedling shoot length while no impact showed by the steckling size on seed germination% (Table 10).

Table 10. Effect of steckling size and cropping location on thousand seed weight, seed germination percentage, seed vigour index and seedling shoot lengrth of Beeralu radish in 2014/15 *Maha*

Factor		1000 seed weight (g)	Seed germination (%)	Seed vigour index	Seedling shoot length (cm)
Location	Sita Eliya (WU)	11.74[a]	89[a]	610[a]	6.8[a]
	Gannoruwa (WM)	11.07[b]	81[b]	536[b]	6.6[b]
Steckling size	Large	11.68[a]	85[a]	602[a]	7.1[a]
	Medium	11.76[a]	86[a]	607[a]	7.0[a]
	Small	10.79[b]	84[a]	510[b]	6.1[b]
CV%		10.86	2.21	5.83	2.13

Means with similar letters within a column for each factorare statistically non-significant at 5% level of probability (DNMRT test)

Table 11. Effect of steckling size and cropping location on seedling root length of Beeralu radish in 2014/15 *Maha*

Factor		Root length at Gannoruwa (cm)	Root length at Sita Eliya (cm)	CV%
Steckling size	Large	12.5[a,y]	14.2a[a,x]	2.26
	Medium	12.5[a,y]	14.2[a,x]	0.85
	Small	11.7[b,x]	12.3[b,x]	1.84
CV%		0.93	1.78	

Similar letterswithin a column (a,b) for locations and within a row (x,y,) for steckling sizes are statistically non-significant at 5% level of probability (DNMRT test).

As indicated in the Table 11, large and medium size stecklings planted in Sita Eliya (WU) recorded significantly higher seedling root length.

Superiority in seed crop growth, seed yield and seed quality in Sita Eliya crops over Gannoruwa crops might be due to the sensitivity of seed production of Beeralu radish to low temperature conditions in Sita Eliya. Similar findings have been reported by Malik *et al*. (1999). Better seed crop development due to more stored food allocations again may be resulted in higher seed yield and seed quality of seeds produced using large and medium stecklings.

Conclusion

Seed production of Beeralu radish is more sensitive to varying environmental conditions and if practiced seed production in Mid Country areas (WM2b), *Yala* is more suitable than *Maha* to produce seeds. If practiced in both seasons, transplanting of stecklings upto mid July in *Yala* and up to the end of December in *Maha* is appropriate to have higher seed yield with better quality. Stecklings longer than 10 cm are the most suitable steckling sizes for seed production of Beeralu radish. Though the root production is impossible, the most favourable conditions for seed production are present under low temperature conditions in Sita Eliya (WU2b). Transplanting of true to type stecklings produced in conducive locations, longer than 10 cm at Sita Eliya (WU2b) taking measures to avoid out crossing is the best option to have good quality, higher seed yield of Beeralu radish. Production of high quality seeds via this method would be beneficial in recapturing farmers to cultivate Beeralu radish instead of cultivating imported long radishes.

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