Research article

Assessing the Yield of a High Yielding Rice Variety, Byaw Htun, Planted Using the Cut-stem Transplant Method and Cultivated in a Deep-water Area, Bago Region, Myanmar

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Abstract Among the five rice ecosystems in Myanmar, submerged and deep-water areas occupy 13.5% of the total cultivated area. If flooding occurs, most rice varieties elongate and lay flat after the water recedes. In such a situation, the lodged stems are cut and transplanted without roots. This cut-stem transplant (CST) method is practiced locally in Ywa Houng village, Thanatpin Township in the Bago Region, using deep-water rice (DWR) varieties such as Pawsan and Yoesein in deep-water areas. However, a high yielding variety, Byaw Htun, is cultivated in the shallow-water areas by using direct seeding (DS) or the normal transplanting (NT) method. Unusual levels of flooding in 2018 resulted in almost all of the fields being subject to deeper water conditions than normal in Ywa Houng village. The highest flood level occurred on 19th July, with a 45cm depth recorded, in what is normally a shallow area (normally less than 25cm depth) and the flood peaked for about 25days. Hence, transplanting of Byaw Htun was delayed until the 10% heading stage in the nursery. Thus, farmers tested the CST method in place of NT method in Byaw Htun. This study examined to clarify the growth and yield of CST method for the Byaw Htun variety. Byaw Htun CST plants exhibit plant growth and yields comparable to those of DS plants. In addition, the yield of Byaw Htun CST was similar to, or higher than those of Pawsan and Yoesein CST. However, the harvesting of Byaw Htun CST took place far later than that of DS areas. Consequently, it was found that CST can be applied for Byaw Htun varieties when the plants were damaged by flooding, but due to delays in harvesting, the application of this method should be considered in relation to any subsequent crops to be cultivated.

Keywords cut-stem transplant, deep water rice, direct seeding, high-yielding rice variety, submerged and deep-water areas

INTRODUCTION

Rice is cultivated on over 7 Million ha in Myanmar, which is more than half of the arable land. There are five rice ecosystems that have been described for Myanmar. These are lowland rain-fed and irrigated, flooded, deep-water, upland and sea water intrusion areas (MOALI, 2015). Among them, flooded and deep-water areas occupy 13.5% of the total area under rice cultivation (Rice Division, 2016). Therefore, construction of flood protection measures, the growing of flood tolerant rice varieties and/or the development of climate resilient cultural practices are necessary to sustain rice production in these areas.

The conventional rice crop establishment methods used throughout the world are direct seeding (DS) and transplanting (NT). In the deep-water areas, dry seeding is fairly common, but transplanting or double transplanting is practiced in some flooded area in Asia (De Datta, 1981**).** Likewise, there is a locally used and adapted method in accord with flooded conditions employed in Ywa Houng village, Thanatpin Township in the Bago region (Mon et al., 2019a). Ywa Houng is situated at the Sittaung River basin area, and monsoon flooding occurs frequently. Therefore, a high yielding variety (HYV) such as Byaw Htun, also a moderate flood tolerant variety, is cultivated in shallow-water areas and photoperiod sensitive deep-water rice varieties (DWR) such as Pawsan and Yoesein in the deep-water areas.

Normally, DS and NT are undertaken in shallow-water areas. Seeding is done after land preparation, which starts when the soil moisture content is sufficient for land preparation. Transplanting in NT method will be carried out when the seedlings are about 35-40 days old. However, seeding time will vary from field to field and depends on the water availability in the nursery field, adjustments being made to coincide with a suitable depth of water in the fields for transplantation, and expected moisture availability for a second crop such as legumes, which require sufficient residual soil moisture. If a second crop will not be cultivated, seeding time will likely be postponed until the water recedes, to escape the possibility of flood damage.

For deep-water areas, dry seeding is done in April-May after the first flash of monsoon and water levels start to increase when the seedlings are 1.5 months old. If the plants are not damaged by flooding, NT is followed. However, if flooding occurs, the plant will respond by elongation of the stem and laid flat after the water recedes. In such a case, the lodged stems are cut and transplanted by using a transplanting fork and the cut-stem transplant method (CST) is practiced (Mon et al., 2019a).

Due to torrential rain in the 2018 monsoon season, abnormal flooding occurred even in relatively higher-level fields, and transplanting had to be delayed until the growth of Byaw Htun in the nursery field reached the late booting stage. Hence, farmers tested the CST on this variety in 2018. Previously CST had only been applied to the DWR varieties such as Pawsan and Yoesein in 2016 and 2017 (Mon et al., 2019a and b), but a HYV, Byaw Htun was planted with the CST method in that 2018 monsoon season. Hence, this survey was conducted with the following objectives.

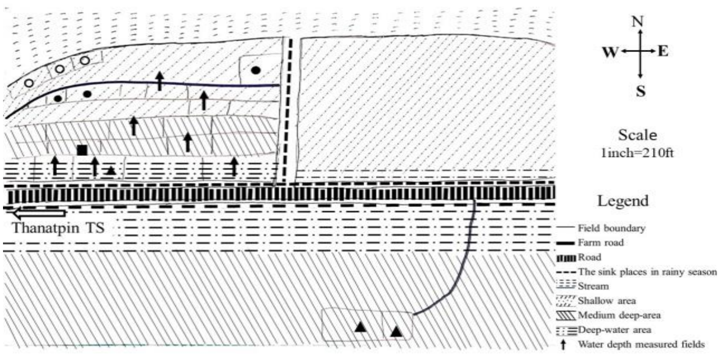
OBJECTIVE

The objectives of this study are (1) to clarify the growth and yield performance of CST comparing with DS planting for Byaw Htun and (2) to compare the yield of CST for Byaw Htun with DWR yields for Pawsan and Yoesein.

METHODOLOGY

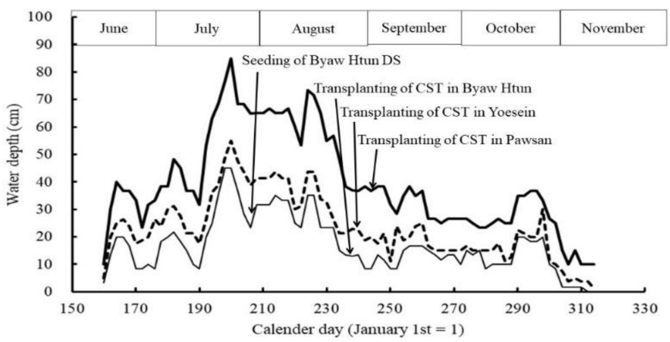
The survey was conducted in Ywa Houng village, Thanatpin Township where the CST method is locally practiced. The location of each harvested field is shown in Fig 1. The water depth was recorded at 2 days intervals, starting from 9th June to the 10th November 2018, by setting of three marking posts at the diagonal of each field. The water depths were measured in 2, 2 and 3 fields for shallow, medium-deep and deep-water areas respectively (Fig 1). Changes of water depth are shown in Fig 2. The water depth was 3, 5 and 10cm in the shallow, medium-deep and deep-water areas at the beginning of June (9th June) (160 calendar days). The water level gradually increased and the peak flooding occurred on 17-19th July (198-200 calendar days) with depths of 45, 55 and 85cm respectively, in each area. Flooding was stagnant for 25 days until 14th August (226 calendar days) and after that, the water depth gradually decreased and finally receded by the end of October (304 calendar days). The seeding date, transplant date and the harvest date of all varieties are shown in Table 1. Although the seeding of Byaw Htun CST was 67 days earlier than that of DS, harvesting was 7 days later. Moreover, the seeding of Byaw Htun CST was 25 days and 18 days later while the harvest date was 26 days and 15 days earlier than those of Pawsan and Yoesein CST. In terms of fertilizer application, Byaw Htun DS and CST fields were applied with urea at 62 days after seeding, and 14 days after transplanting (DAT) with the rate of 21 kg ha^{-1} and 42 kg ha^{-1}, respectively. Similarly, Pawsan and Yoesein CST were applied with urea at 15 DAT and 16 DAT with the rate of 63 kg ha^{-1} and 42 kg ha^{-1}, respectively.

Sampling was done at harvest in farmers' fields by sampling seven $1m^2$ plots in each field along the transverse of the field's diagonal to determine the yield rates, and hill density was recorded at these plots. In addition, samplings of 10 hills for each $1m^2$ plot in the DS fields and 5 hills each for the CST fields were randomly excavated near each plot, to measure the growth and yield components.



○ Byaw Htun DS ● Byaw Htun CST ▲ Pawsan CST ■ Yoesein CST

Fig. 1 Map of the sampling plots situated in north west part of Ywa Houng village



Continuous thick line: deep-water area, Dotted line: medium-water area, Continuous thin line: shallow-water area.

Fig. 2 Changes of the water depth at three locations of the paddy fields in Ywa Houng village, Thanatpin Township, Bago Region, Myanmar (2018)

Table 1 Outline of cultivation methods of Byaw Htun, Pawsan and Yoesein

Varieties	Cultivation method	Seeding			Seedling age (days)	Transplant date	Growth stage at transplant	Harvest date	Growth duration (days)*
		Method	Date	Rate (kg/ha)					
Byaw Htun	DS	WSR	27-Jul	103	-	-	-	20-Nov	116
	CST	WSR	20-May	103	96	24-Aug	10% heading	27-Nov	191
Pawsan	CST	DSR	25-Apr	224	129	1-Sep	Tillering	23-Dec	242
Yoesein	CST	DSR	2-May	103	117	27-Aug	Tillering	12-Dec	224

**: days from seeding to harvest, WSR: Wet seeded rice, DSR: Dry seeded rice, DS: Direct seeding, CST: Cut-stem transplant*

The plant samples were washed for removing the soil and hung for one week. After that, the growth parameters and yield components were measured. When measuring the growth parameters in CST, the two types of plants were observed; the main stem existing, and the main stem died and only the tillers existing. About 25% of the plant samples in Byaw Htun CST were the main stem died. The plants of which the main stem died were skipped to count the number and the length of elongated nodes. For statistical analysis, the average value of each fields resulting from 7 harvested plots was regarded as one replication. The data were analyzed by using Statistix version 8.0 and mean separation was done at Least Significant Distance (LSD) at a 5% level.

RESULTS AND DISCUSSION

Comparing the Growth and Yield of CST and DS in Byaw Htun

The internode elongation patterns of CST and DS in Byaw Htun are shown in Fig 3 (A). In both CST and DS, the basal internodes (1st to 3rd) were almost the same length and after that there was an increase from 4th internode to succeeding nodes. However, the basal internodes' lengths of DS were shorter than comparable nodes of CST plant. It showed that a DS plant was not affected by flooding at the vegetative stage. Because, the DS fields were located on the river bank, drainage of excess water was easier (Fig 1) and seeding was done after flooding.

The growth parameters of Byaw Htun DS and CST are shown in Table 2. The plant length, culm length, panicle length, the number of elongated nodes and the number of roots per hill of CST were similar and not significantly ($p<0.05$) different than those for DS plants. All the shoot dry weight (g) showed no significant difference except the shoot dry weight per stem. Yields and yield components are shown in Table 3. The hill density of CST (29.2) was about half of DS (63.6). However, the number of panicles per hill was higher in CST. The number of grains per panicle was not statistically different between the two methods. In addition, filled grain (%) and 100 grains weight were not significantly different, as well. Finally, the yield (g/m^2) of CST (412.7 g/m^2) was not significantly different from that of DS (400.3 g/m^2). Although, the grain yield of Pawsan DS was lower than that of CST in Ywa Houng village (Mon et al., 2019b), similar yield in Byaw Htun DS and CST were due to the field location and cultivated condition. DS in this experiment was cultivated in the shallow area, not affected by flooding and being able to apply fertilizer during the plant development. Therefore, it could produce the plant growth and yield comparable to that of CST.

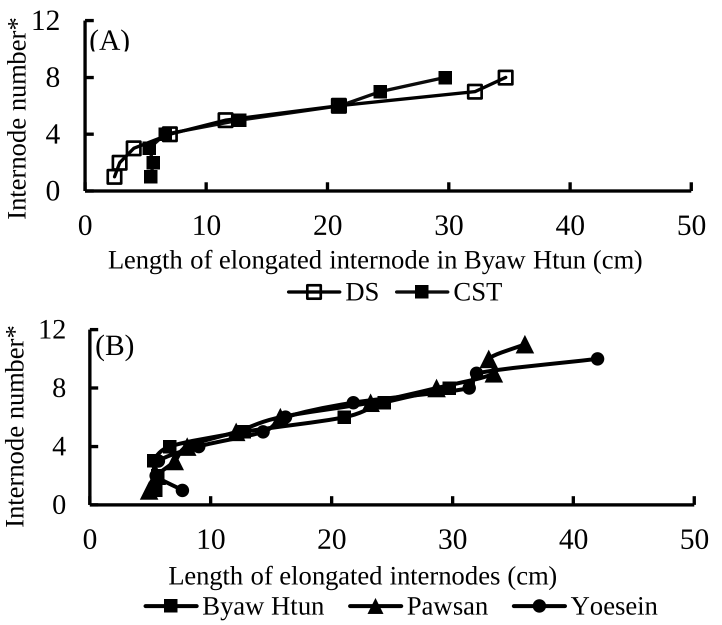


Fig 3 Internode length of each elongated internodes of DS and CST in Byaw Htun (A) and CST in Byaw Htun, Pawsan and Yoesein (B)

** Node number count from the stem base*

Despite the yields of these two methods were similar, the growth duration of CST was 75 days longer than that of DS (Table 1). Because, Byaw Htun was photoperiod insensitive HYV and maturity was depended on the growth duration. After transplantation, some of the main stem died and the tillers were produced from the remaining nodes of the stem. CST plants reset the growth from the tillering stage although it was transplanted at 10% heading stage. Therefore, the growth duration was longer than that of DS. In addition, CST needed high cultivation cost especially transplantation cost than that of DS. Therefore, in consideration of the cost and labor for the CST transplantation and the effective use of the paddy field, CST in Byaw Htun would not be applicable in the area where the flooding is not use to occur.

Table 2 The plant growth parameters of Byaw Htun cultivated with direct seeding and cut-stem transplant method

Cultivation method	Plant length(cm)	Culm Length (cm)	Panicle Length (cm)	No. of nodes	No. of roots per hill	Shoot dry weight (g)		
						(/stem)	(/hill)	(/m²)
DS	108.5a	84.0a	24.5a	7.2a	252.1a	6.9a	28.6a	1038.1a
CST	98.7a	76.6a	21.4a	6.9a	474.9a	4.6b	19.1a	816.2a

**DS: Direct seeding, CST: Cut-stem transplant, Values followed by the same letter within each column do not different at $p<0.05$ by using statistix version 8.0*

Table 3 Yields and yield components of Byaw Htun cultivated with direct seeding and cut-stem transplant method

Variety	Hill density	No. of panicle per hill	No. of grains per panicle	Filled grain (%)	100 grains weight (g)	Yield (g/m²)
DS	63.6	2.8	166.2	63.78	2.34	400.3
CST	29.2	6.7	138.6	72.06	2.26	412.7

**DS: Direct seeding, CST: Cut-stem transplant, Values followed by the same letter within each column do not different at $p<0.05$ by using Statistix version 8.0.*

Comparing the Growth and Yield of Byaw Htun CST with those of Pawsan and Yoesein

The pattern of internode elongation among CST is shown in Fig 3 (B). The internode elongation patterns of Byaw Htun, Pawsan and Yoesein CST were similar in that the internode length from the 1st to 3rd nodes were short and then the length gradually increased from the 4th to the higher nodes. It showed all CST developed under similar field condition. However, the number of elongated nodes in Byaw Htun (6.9 nodes) was less than those of Pawsan (8.2 nodes) and Yoesein (8.7 nodes) and it could depend on the plant type. Byaw Htun was a photoperiod insensitive HYV while the other 2 varieties (Pawsan and Yoesein) were photoperiod sensitive DWR. There was a correlation between the number of elongated internodes and the vegetative growth period in DWR and local rice varieties, while no correlation was found in the semi-dwarf cultivar (Hamamura, 1978). Hence, the number of elongated nodes of Byaw Htun might be expected to be less than those of Pawsan and Yoesein. In addition, the younger seedling age and the shallower field condition in Byaw Htun causes a smaller number of elongated nodes than DWRs.

The growth parameters of Byaw Htun and Pawsan are compared in Table 4. Among the plants following CST method, plant length, culm length and number of nodes of Byaw Htun were the lowest while those of Pawsan and Yoesein showed a very similar value. However, the panicle length (cm) of Byaw Htun was not significantly different from those of Pawsan. The number of roots per hill of Byaw Htun was the lowest, although it was not significantly different from Pawsan. The shoot dry weight per stem and per hill of Byaw Htun were significantly less than those of Pawsan, though the shoot dry weigh per m^2 of Byaw Htun was not significantly different due to higher hill density in Byaw Htun. The yields and yield components are shown in Table 5. Among the varieties, the hill density of Byaw Htun was the highest followed by Yoesein and Pawsan. In contrast to that, the number of panicles per hill of Byaw Htun was significantly lower than other varieties. Whereas, the number of grains per panicle of Byaw Htun was statistically higher than that of Pawsan. Filled grain (%) of Byaw Htun and Yoesein was higher than that of Pawsan. Because the grain filling period of Byaw Htun was earlier than those of Pawsan and Yoesein by 26 days and 15 days, the availability of soil moisture for grain filling of Byaw Htun was higher than those of Pawsan and Yoesein. However, the 100 grains weight of Byaw Htun was the lowest due to small grain size. Yields (g/m^2) of Byaw Htun (412.7) was the highest, followed by Yoesein (291.9) and Pawsan (286.7) although this did not represent a significant difference between Byaw Htun and Pawsan. Because of the earlier maturity in Byaw Htun, the moisture availability at grain filling would be higher than those of Pawsan and Yoesein. In some years, the rainfall finishes early and moisture deficit affecting the grain yield occur in the late harvested varieties especially Pawsan. Under such condition, Byaw Htun would produce significantly higher yield than that of Pawsan particularly in Ywa Houng village where no irrigated water was available for grain filling. Therefore, Byaw Htun can be followed with CST in the deep-water area if the flood damage occurred.

Table 4 The growth parameters of Byaw Htun, Pawsan and Yoesein cultivated with cut-stem transplant method

Variety	Plant length (cm)	Culm Length (cm)	Panicle Length (cm)	No. of nodes	No. of roots per hill	Shoot dry weight (g)		
						(/stem)	(/hill)	($/m^2$)
Byaw Htun	98.1b	76.6b	21.5a	6.9b	474.9a	4.6b	28.6b	816.1a
Pawsan	141.5a	117.4a	24.1a	8.2a	561.5a	7.0a	66.1a	867.3a
Yoesein*	152.5	127.5	24.2	8.7	566.9	5.9	41.6	842.3

*Analysis was done for Byaw Htun and Pawsan only by using statistix version 8.0, * No replication. value followed by the same letter within each column do not different at $p< 0.05$.*

Table 5 Yields and yield components of Byaw Htun, Pawsan and Yoesein cultivated with cut-stem transplant method

Variety	Hill density	No. of panicles per hill	No. of grains per panicle	Filled grain (%)	100 grain weight (g)	Yield (g/m^2)
Byaw Htun	27.1a	6.7b	138.6a	72.06a	2.26b	412.7a
Pawsan	13.4b	11.6a	94.3b	61.17b	3.24a	286.7a
Yoesein*	20.4	6.7	105.2	69.05	2.97	291.9

*Analysis was done for Byaw Htun and Pawsan only by using statistix version 8.0, * No replication, value followed by the same letter within each column do not different at $p<0.05$*

CONCLUSION

Although CST in Byaw Htun can be transplanted, it took longer growth duration than that of DS. Therefore, CST in Byaw Htun should not be followed in the area where no flood damage occurs and the second crop such as legume will be cultivated after rice harvest. However, Byaw Htun CST produce the yield comparable to those of Pawsan and Yoesein CST. Moreover, it can harvest earlier than those of Pawsan and Yoesein. Therefore, CST in Byaw Htun could be practiced in the area where the flood damage occurred.

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