RICE SEEDLING AGE INFLUENCES YIELD ATTRIBUTES IN RAINFED CONDITION

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ABSTRACT

Due to drought condition, many rice farmers are bound to transplant old age rice seedlings, which induced to decrease in grain yield in regard less of applying other inputs. Transplanting of early stage seedlings is one of the no cost inputs to maintain and prevent decrease in the rice grain yield. Four drought resistant rice genotypes were included in the study. Seedlings of 25, 35 and 45 days old were manually transplanted and cultivated in rainfed condition at the Regional Agricultural Research Station, Banke, Nepal from 2014 to 2016. Three years findings revealed that days to maturity were significant (p value = 0.000) earlier (at least 2 days) in 25 days seedlings compared to old aged seedlings. Plants grew 3.8 cm (p value = 0.001) taller when transplanted 25 days seedlings as compared to later days. Panicles were 1.3 cm (p value = 0.013) longer when transplanted 25 days old nursery seedlings. Rice grain yield was highest (p value = 0.037) in the plots in 25 days old seedling (4,647 kg per hectare) which was 500 kg higher when compared with 10 days later transplanted. Therefore, 25 days old nursery seedlings should be transplanted in the rainfed condition which is resilient to drought condition.

Keywords: Climate change, manual transplanting, on station experiment, *Oryza sativa* L.

INTRODUCTION

Rice has become a symbol of Asian civilization. Rice eating habit is now engraved in the Asian culture as a part of daily dietary meal. Along with Asians, half of the world population eats rice as a main source of calorie (GRISP, 2013). With the burgeoning world population, demand for rice is increasing and will increase in the future as well. Hence, rice farmers have huge responsibility for the future. As an option to increase the grain yield, rice farmers use different inputs like chemical fertilizers, irrigation, improved and hybrid seeds and other management options. Most of inputs add cost of cultivation and has side effects

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as well. For example, one of the mostly adopted practice of nitrogen fertilizer use has caused greenhouse gas emission from the rice farm lands (Shrestha, 2012). Whereas, one of the non-cost input to increase or maintain grain yield is transplanting rice seedlings at the early age and on time (Aslam *et al.,* 2015; Naresh, 2012).

In the recent years, late transplanting in the rice fields prepared through puddling (Lama and Marahatta, 2017) has become more common among Nepalese rice farmers. Late transplanting has two meanings; one is late in the sense of date of transplanting and other is old aged seedlings. Rice seedlings of upto 25 days after nursery seed bed establishment are called normal seedlings and later than this are called old seedlings (Liu *et al.,* 2017). Normal date of transplanting is considered 15 June to 15 July in Nepal. Transplanting later than 15 July results into shorter growing period, delay in maturity ultimately leading to less yield.

One of the main reasons for late transplanting is climate change. Changing climate has altered the onset of South Asian monsoon rainfall (Turner and Annamalai, 2012) from few days to weeks in the recent years, which includes both delay (Nayava, 2017) and advance (THT, 2018) in the monsoon initiation. However, farmers who prepare rice seedbed in their traditional cropping calendar without considering the changed monsoon pattern fall into victim of transplanting either aged seedlings or very young seedlings. Hence, rainfall dependent farming system and lack of irrigation infrastructure (MOAD, 2018) are one of the main factors resulting late transplanting. In addition to that, lack of accurate weather forecasting system reaching every farmer in the country and past experience based rice farming practice also leads to aged seedling transplanting (Regmi *et al.,* 2018). Another reason for late transplanting is lack of mechanization (Kafle and Paudel, 2018). With the start of monsoon, all farmers start their farming activities from land ploughing to transplanting. Many farmers still depend on ox/bullocks to plough and prepare their land. Among different methods of seedling establishments (Chen *et al.,* 2017), machine transplanting is still in early age (Bhatt *et al.,* 2014) whereas seedling throwing is practiced in very few places in Nepal. Most of the farmers do manual transplanting than direct seeding. In the context of labor scarcity during peak seasons in the rural areas (Shrestha, 2012), farmers who start early are able to transplant their seedlings timely. However, small farmers are bound to transplant aged seedlings and late as well.

Rice seedling age has important role in the plant height, number of tillers per hill, number of effective tillers, panicle length, number of grains per panicle, grain yield, and straw yield (Aslam *et al.,* 2015). Younger the seedling means less transplanting shock which helps to rejuvenate quickly. In addition, early date transplanting gives plant longer time to uptake nutrients like nitrogen, phosphorus and potash (Kumar, 2001) for better growth and development. It means better root growth, better establishment, more stem elongation, more leaves and more tillers compared to late transplanting. Kumar (2001) explained long duration varieties results into more tillers when transplanted earlier than 60 days of nursery establishment, hence transplanting older seedling produced lesser tiller. Furthermore, Liu *et al.,*(2017) explained dry matter stored in vegetative organs before their heading stage are the source of carbohydrate for grain filling stage. Therefore, longer vegetative growth period means more carbohydrate in storage. All these effects leads to higher grain yield when early age seedling transplanted (Naresh, 2012). Moreover, early transplanting has shown to increase irrigation water productivity (Brar *et al.,* 2012) as well. Whereas, late transplanting causes more non-effective tillers and higher straw yield (Sarkar *et al.,* 2011). Late transplanting also resulted into higher pest infestation (Singh and Timsina, 1994) causing grain yield loss.

Different growth environments have dissimilar effect of seedling age on rice yield attributes. Rice can be grown three time a year in the sub-tropical to tropical environment; main season (June to November), winter (November to March) and spring (March to June) (GRiSP, 2013). Among them, winter rice seedlings have no significant effect in the yield attributes due to its long and slow growth rate during the winter (Ali *et al.,* 2013). Similarly, for the long duration varieties of 120 to 150 days, transplanting seedlings of age 25 to 65 days have little effect (Bhurer and Adhikari, 2001). In the Mediterranean climate, Mobasser et al.(2007) and Faghani et al.(2011) found no significant effect of seedling ages when transplanted at 25, 35 and 45 days after sowing.

Pasuquin *et al.,*(2008) revealed delay in transplanting later than seven days of sowing has decreased rice grain yield upto one ton per hectare in Philippines condition. However, in Nepal's climatic condition, getting manually transplantable seedling by seven days of nursery establishment is not a practical option. We need research results conducted with 20 days or later transplanting in the alike climate. There are researches in irrigated condition; however, performance of drought resistant genotypes in rainfed condition is not yet discussed. Hence, this research was conducted to find out changes in the yield attributes when rice seedlings are transplanted later than optimum seedling age in rainfed condition.

MATERIALS AND METHODS

Four drought resistant rice genotypes (Table 1) were tested from National Rice Research Programme (NRRP), Hardinath, Dhanusha. The research was carried out during three main rice seasons in 2014, 2015 and 2016 (Table 2) at Regional Agricultural Research Station (RARS), Khajura, Banke (Latitude: 28°6'47.63", Longitude: 81°35'34.56", altitude: 152 m) of Nepal Agricultural Research Council. These genotypes were transplanted manually at three ages of seedlings i.e. 25, 35 and 45 days after sowing in the split plot design with three replications (Figure 1). The plot size was 2 m x 3 m. Effective plot size was 4.8 m^2.

Fertilizer dose was 60 kg nitrogen, 30 kg P_2O_5 and 30 kg K_2O. As a basal dose, full dose of phosphorus from diammonium phosphate (DAP) containing 46% P_2O_5 and 18% nitrogen, potash from muriate of potash (MoP) containing 60% K_2O and nitrogen through urea containing 46% nitrogen was applied. One third of the nitrogen fertilizer was applied as a basal dose, followed by one third after 21 days of transplanting and last portion before panicle initiation. Two rice seedlings were transplanted at the crop geometry of 20 cm x 20 cm.

Table 1: Rice genotypes used for seedling age experiment at RARS, Khajura, Banke during 2014 to 2016

Genotype ID	Genotypes
V1	IR83381-B-B-137-1
V2	IR83376-B-B-71-1
V3	IR87707-446-B-B-B
V4	IR83383-B-B-129-4

The following Table 2 depicts the crop calendar during three experimental years.

Table 2: Date of rice nursery bed establishment and transplanting for seedling age experiment at RARS, Khajura, Banke in 2014, 2015 and 2016

Year	Nursery bed establishment date	First transplanting date (D1)	Second transplanting date (D2)	Third transplanting date (D3)
2014	30 June	25 July	4 August	14 August
2015	2 July	17 July	27 July	6 August
2016	21 June	15 July	25 July	4 August

RI			RII			RIII		
D1	D2	D3	D1	D2	D3	D1	D2	D3
V1	V1	V1	V4	V4	V4	V3	V3	V3
V2	V2	V2	V3	V3	V3	V4	V4	V4
V3	V3	V3	V2	V2	V2	V1	V1	V1
V4	V4	V4	V1	V1	V1	V2	V2	V2

Figure 1. Split plot research design for seedling age experiment in rice at RARS, Khajura, Banke during 2014 to 2016

METEOROLOGICAL CONDITION

Banke district experiences highest maximum temperature in Nepal (Shrestha et al., 2017). Total rainfall during the rice crop growing season was 1213.3 mm, 1367.2 mm, 752.6 mm in the year 2014, 2015 and 2016. Maximum temperature (°C), minimum temperature (°C), relative humidity (%) and rainfall amount (mm) during the crop period are shown in the Figure 2.

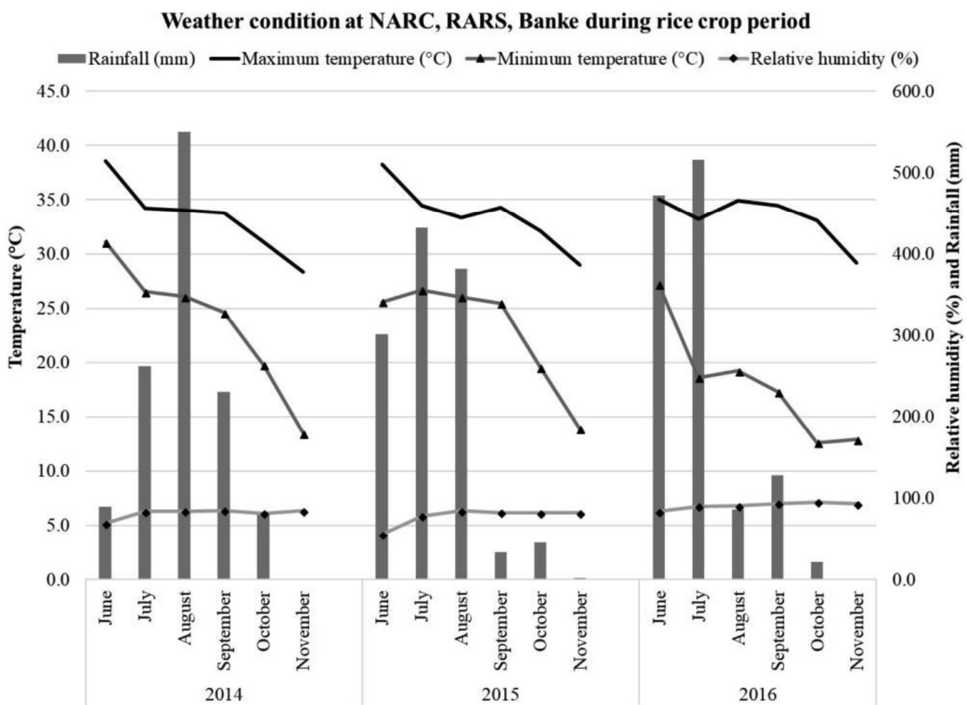

Figure 2. Weather condition at RARS, Banke, NARC during rice crop period from 2014 to 2016

RESULTS AND DISCUSSION

DAYS TO MATURITY

Early age transplanting (25 days seedling) resulted in the significant (p value = 0.000) early maturity compared to later transplanting (45 days seedling). Days to maturity was at least two days earlier with the early age seedling transplanting compared to late transplanting. In Andra Predesh, India, Naresh (2012) found upto seven days earlier maturity when transplanted from 20 to 60 days seedling. In contrast to our results, in Parwanipur condition (Shah and Yadav, 2000) found earlier maturity of old aged seedlings compared to young ones. They used September transplanting, in this month maximum temperature is already declining, which caused premature anthesis.

Among four varieties, IR83381-B-B-137-1 matured late (130 days), which is significant to other dates (p value = 0.0023). There was a significant (p value = 0.037) interaction effect of seedling age and variety in maturity days by two days. There was a significant (p value = 0.0007) interaction effect of seedling age, variety and year in the maturity days.

PLANT HEIGHT

Early age transplanting resulted in the significant (p value = 0.001) taller plants. Plant height increased by 4 cm in the early age transplanted seedlings. With longer time to grow, plants were able to store more photosynthates for taller plants (Sarkar et al., 2011). On a par with these results, Naresh (2012) found upto 9 cm taller plants when compared seedlings of age 20 to 60 days in Andra Pradesh, India.

Among four varieties, IR87707-B-446-B-B-B had significant (p value = 0.000) shorter plants than other three. Overall, plants were significant (p value = 0.0012) shorter in year 2016 than previous years.

PANICLE LENGTH

Panicle was significant longer in the early age transplanting than later transplanting. Similarly, Naresh (2012) found 1.1 cm longer panicles in Andra Pradesh, India. For hybrid varieties, Kumar (2001) revealed 1 cm longer panicles when transplanted 20 days than 25 and 30 days seedlings.

There was a significant (p value = 0.0002) effect of year on panicle length with least in the year 2016.

GRAIN YIELD

There was a significant decline in the rice yield when older seedlings later than 25 days were transplanted (Table 3). In concordance with these results, Naresh (2012) revealed grain yield decline at the rate of 676 kg per hectare when transplanted later than 20 days seedlings for long duration varieties. Similarly, for hybrid varieties Kumar (2001) found 414 kg decrease in grain yield when compared 20, 25 and 30 days seedlings at New Delhi, India.. Many authors (Adhikari *et al.,* 2004; Gautam *et al.,* 2010; Mahato and Pathic, 1997; Naresh, 2012) have shown significant decline in the grain yield when 20 days seedling was compared with 65 days. Saphi *et al.,*(2015) revealed 20 to 30% yield decline when 35 to 55 days old seedlings were transplanted compared to 25 days seedling. Supporting these results, Alam et al., (2002) resolved significant less grain yield when very young seedling (21 days) was transplanted compared to 28 to 35 at Mymensingh, Bangladesh.

In agreement with *Oryza sativa* cultivars, Liu *et al.,*(2017) reported significant higher grain yield in younger seedlings when compared 25, 30 and 35 days seedling of *Oryza japonica* cultivar in Shandong, China.

Meta-analysis (Adhikari *et al.,* 2004; Mahato and Pathic, 1997; Saphi *et al.,* 2015) including results of this research (Figure 3) revealed age of seedling have strong effect in the rice yield (adjusted R^2 value = 0.63, p value = 0.0001). These results supported 25 to 30 days seedlings for the highest rice grain yield.

However, Shah and Yadav (2000) showed no significant effect in grain yield when seedlings of 25 and 50 days were transplanted on the same date. It was due to heavy plant hopper attack (Shah and Yadav, 2000).

Among four varieties, IR83383-B-B-129-4 produced significant (p value = 0.0114) less grain yield (3763 kg/ha) whereas other three produced grain yield at par.

During three years of experiment, 2016 produced significant (p value = 0.0004) high grain yield than other years. It was due to higher June rainfall and distribution of monsoon rainfall (Figure 2). Shrestha *et al.,*(2017) found significant effect of June rainfall in the rice yield.

Table 3: Agronomic performance of four drought tolerant rice genotypes transplanted at 25, 35 and 45 day seedling age during main rice season of 2014, 2015 and 2016 at RARS, Banke of NARC.

Seedling age	Variety	Maturity days	Plant height (cm)	Panicle length (cm)	Grainyield (kg/ha)
25 days	IR83381-B-B-137-1	122	110.8	23.9	5078.63
	IR83376-B-B-71-1	121	110.6	24.3	5026.08
	IR87707-B-446-B-B-B	122	102.1	23.4	4515.76
	IR83383-B-B-129-4	122	109.2	23.3	3967.67
35 days	IR83381-B-B-137-1	129	107.6	22.2	4361.08
	IR83376-B-B-71-1	129	106.7	24.2	4402.56
	IR87707-B-446-B-B-B	127	102.3	22.7	3893.21
	IR83383-B-B-129-4	127	106.8	21.8	3738.93
45 days	IR83381-B-B-137-1	139	103.0	21.5	4145.78
	IR83376-B-B-71-1	137	99.7	22.2	4134.19
	IR87707-B-446-B-B-B	137	94.8	21.4	4097.16
	IR83383-B-B-129-4	137	101.0	21.4	3595.26
Seedling age	25 days	122	108.2	23.7	4647.01
	35 days	128	105.9	22.7	4095.78
	45 days	138	99.6	21.6	3993.09
	CV (%)	0.92	7.0	10.9	23.73
	p value	0.000	0.001	0.013	0.0372
	LSD value	2	3.8	1.3	517.34
Varieties	IR83381-B-B-137-1	130	107.1	22.5	4528.49
	IR83376-B-B-71-1	129	105.7	23.6	4520.94
	IR87707-B-446-B-B-B	129	99.7	22.5	4168.67
	IR83383-B-B-129-4	128	105.7	22.1	3763.07
	CV (%)	1.03	5.2	5.0	22.05
	p value	0.0023	0.0000	0.0001	0.0114
	LSD value	2.16	3.0	1.0	510.75
Seedling age * Variety	**p value**	0.037	ns	ns	ns
	LSD value	2.1			
Year	2014	130.2	113.8	22.5	3172.06
	2015	129.0	105.8	24.0	4688.83
	2016	127.7	94.1	21.5	4875.00
	p value	ns	0.0012	0.0002	0.0004
Seedling age * Variety * Year	**p value**	0.0007	ns	0.0572	ns

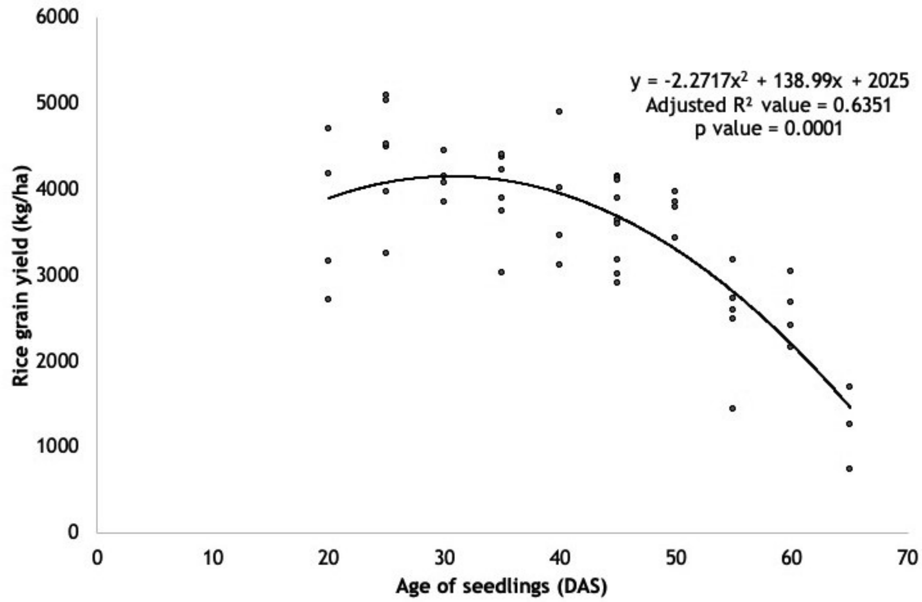

Figure 3. Effect of age of rice seedlings in the rice grain yield (meta-analysis)

CONCLUSIONS

For rainfed condition, manual transplanting of drought tolerant varieties should be done between 25 to 30 days of nursery establishment. Transplanting later than 30 days causes significant grain yield loss. This result is valid for the rice growing areas for the South Asian monsoon season where rice is transplanted in the puddled lands. As this is the no cost input for sustainable rice production, it should be considered and utilized by all the farmers.

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