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EFFECT OF DIFFERENT WATER DEPTHS ON PLANT POPULATION AND RICE (Oryza sativa) YIELD AT TIME OF TRANSPLANTING USING MECHANIZED TRANSPLANTER

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Abstract— Studies were conducted at experimental fields of Rice Research Institute, Kala Shah Kaku for two years (2010 to 2011) in order to ascertain the effects of different surface water levels at the time of mechanical rice transplanting on plant population in terms of number of missing hills and rice productivity. A six row self propelled paddy transplanter was used for the purpose. As control treatment, rice transplanting was also carried out on muddy soil condition. Three water depths of 2.5, 5.0 and 7.5 cm were taken in account; each water depth was replicated four times. Nursery for transplanting was raised on mate type plastic trays. The results indicated that maximum paddy yield (5.20 t/ha) was obtained where water depth at transplanting time was maintained at 2.5 cm followed by transplanting in 5.0 cm water depth where the paddy yield was 4.76 t/ha. The minimum paddy yield (4.12 t/ha) was obtained where 7.5 cm water depth at transplanting time was maintained. Surplus or more than required water at transplanting time resulted in reduced growth and significantly decreased the number of missing hills m-2 which ultimately reduced the required number of plant population per acre. It was estimated that increased water depth (7.5 cm) at transplanting time decreased paddy yield by 26.2 %. However, in case of transplanting at 2.5 cm water level, maximum yield was obtained primarily due to highest number of hills per meter square, followed by increased number of productive tillers per plant and number of fertile grains per panicle.

Index Terms— Rice, Mechanized transplanting, Water levels, Missing hills, Yield components, Paddy yield

1 INTRODUCTION

Rice as a staple food can never be neglected. Rice being one of the richest starchy foods is a principal food crop of about half the world's population (Martin, 1986). In Pakistan, it is the most important kharif cereal. It occupies a significant position in the economy of country. It has emerged as a major export commodity, contributing about 27% to the total foreign earnings of Pakistan (Anonymous, 1990). There are number of factors that influence crop yield. These include fertilizers (Iqbal et al., 1987; Chaudhry et al., 1990; Chaudhry & Rafique, 1990), plant density (Kahlown et al., 2000), optimum farm management (Kahlown et al., 1997), timely availability of agricultural inputs (Ali et al., 1994), resource conservation (Raza et al., 2001), and farmers inputs (Junejo et al., 2001).

Keeping a glance on rice crop, the water application and transplanting method of seedlings are also main factors which can decide the yield potential. So there is a need of producing such rice production packages which not only strengthen the slogan of precision agriculture but also responsible for optimum paddy yield. Conventionally rice is considered as a hydrophytic or water loving crop but the severe water shortage in the country has forced the rice researchers to determine the suitable level of water at transplanting for rice crop. In Pakistan, rice is largely grown by manual transplanting of seedlings which is quite expensive and requires lot of labor besides involving lot of drudgery. Farm labor usually does not transport required number of plants per acre which decreases the paddy yield by 20-25%. Only 50000 to 60000 plants are found in the farmer's field whereas recommended plant population is 80000 per acre. Singh et al., (1985) reported that transplanting takes about 250-300 man hours ha-1 which is roughly 25 per cent of the total labour requirement of the crop. Further, due to rapid industrialization and migration to urban areas, the availability of labour became very scarce and with hike in the wages of labour, manual transplanting found costly leading to reduced profits to farmers. Under such circumstances a labour saving method of rice transplanting with higher yield is the urgent need (Tripathi et.al, 2004). In such conditions, the mechanical transplanting of rice seems to be the most favorable approach as it saves labour, ensures timely transplanting and attains optimum plant density that contributes to high productivity. Besides this less transplanting shock, early vigour of seedling, better tillering and uniform maturity of crop facilitate timely harvest and reduce harvest losses. It sounds well that this method ensures less incidence of diseases due to less root injury. The present experiment was designed to study the effect of different soil surface water levels at the time of mechanical rice transplanting on number of missing hills and rice productivity.

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2 Materials and Methods

The study was conducted on experimental fields of Rice Research Institute, Kala Shah Kaku during 2010 and 2011. A six row self-propelled paddy transplanter was used for the purpose. Rice transplanting was carried out on muddy soil condition. Three water depths of 2.5, 5.0 and 7.5 cm were taken in account; each water depth was replicated four times. Nursery for transplanting was raised on mate type plastic trays. For the study, approved rice variety i.e. Super Basmati was used. The experiment was conducted for two consecutive years (2010 & 2011) employing randomized complete block design with 04 replications and a plot size of 15X40 m-2 on a clay loam soil. Physical properties of the soil of experimental site are depicted in table 1.

Rice nursery was sown on mate type plastic trays with clean seeds on 16th June during both the years i.e. 2010 & 2011. Raising of rice nursery in plastic trays is the requirement of the Mechanical Rice Transplanter. The size of the tray was 60 cm long, 30 cm wide and 3 cm high. Sieved soil was used by mixing it with single super phosphate (SSP) fertilizer (3 kg soil+300 g SSP per tray). Seed rate of rice was 10 kg per acre. The seed was soaked in fungicide solution @ 2.5 g/kg seed for 24 hours and then kept under shade in the form of a heap covered with a gunny bag for 36 hours for initial sprouting. The trays were filled with soil mixture upto 3 cm depth, leveled and moisten with water properly. Sprouted seed spread evenly on each tray by seeding machine, leaving no space without seed in the tray. Then seed covered with a thin layer of soil mixture. After seeding, the trays were covered with tarpaulin for two to three days. Germinated were then were shifted on a well leveled field, applied urea fertilizer to the 100 nursery trays @ 250 grams after 15-18 days of seedlings and irrigation applied when required. Four treatments including mechanized transplanting in muddy soil as control, mechanized Transplanting in 2.5, 5.0 and 7.5 cm standing water levels.

TABLE 1
Physical Properties of the Soil of Experimental Site at Experimental Fields of RRI, KSK

Fine Sand	Coarse Sand	Silt	Clay	Clay Ratio	Soil Texture
21.50	1.30	31.20	46.71	0.47	Clay Silt Loam

The land was prepared by two ploughings each followed by planking with the help of a tractor drawn cultivator seven days before transplanting and leveled the soil using laser land leveler to achieve the precision leveling. Nursery was transplanted at the age of 25 days. A fertilizer dose of 133-85-62 kg N.P.K. ha-1 in the form of urea, single super phosphate and sulphate of potash was applied to the experiment. Transplanting was done on 12th July each year using six row rice transplanter (YANMAR) at 30 cm row-to-row and 15 cm plant-to-plant distance. Zinc Sulphate (22%) was applied @ 25 kg ha-1. All other agronomic requirements of crop were kept optimum. The crop was harvested at full physiological maturity at 20-22 % grain moisture level. Data on paddy yield and yield components were recorded. The data were subjected to analysis of variance and means were separated using least significant difference (LSD) at 0.05 probability (Steelk and Tonie, 1984).

Plant height of 20 primary tillers selected randomly from each of the experimental unit was recorded from soil level to the tip of flag leaf with the help of a meter rod and then averaged. The number of panicle bearing tillers were recorded at harvesting time from three different places in each plot and averaged to calculate the number of tillers m-2. Twenty panicles of productive tillers were randomly selected at harvesting time to determine the number of grains per panicle. Thousand grain weight (g) from each experimental unit was recorded using electronic balance. After harvesting and threshing, the clean paddy was air-dried and weighed at 14% moisture level. Moisture content in the grains was determined by using Grain Moisture Meter.

3 Results and Discussions

During this study, the variation of water depths showed effective impact on the growth as well as productivity of the rice crop, in terms of plant population per meter square, number of tillers per plant and number of grains per panicle during first and second year respectively.

3.1 Plant Height (cm)

Different water depths at the time of mechanical transplanting of rice (Table 2 & 3) reveals that there was a significant difference in plant height during both years of study. Maximum plant height (120.20 cm) was found where water depth was kept 2.5 cm at the time of mechanical rice transplanting (Table 2). The minimum plant height (118.10 cm) was observed during 2011 (Table 3) where water depth was kept 7.5 cm at the time of transplanting. This might be due to heavy quantity of water at the time of transplanting which ultimately reduced the plant growth slightly. These results are inconformity with that of Junego et al (2001) and Talpur et al. (2013). They also observed decrease in plant height with increasing water depth at transplanting. It was concluded from their study that the maximum plant survival and tallest average plant height were recorded in 5 cm water depth (minimum) from cultivation till to mid stage of growth (Talpur et al. 2013). Fig 1 clearly reflect the impact of various water depth levels at the time of mechanized rice transplanting as average of both the study years (2010 and 2011). The graphs show that maximum average yield (5.20 t/ha) was obtained when the water depth at the time of transplanting was maintained at 2.5 cm. At the same level of water depth, maximum average plant length (121 cm) was also attained by the crop. When the water depth was further increased, a sharp reduction in average plant height as well as in yield was observed (fig 1).

3.2 Number of Prouctive Tillers per Plant

The results regarding number of productive tillers at the time of crop harvesting (Table 2 & 3) indicates that all the four treatments had significant impacts on number of productive tillers during both the years. Maximum number of productive tillers per plant (22.55 tillers) were found in case where water depth at transplanting time was kept 2.5 cm whereas minimum number of productive tillers per plant (18.11 tillers) were

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found in case where water depth at transplanting time was kept 7.5 cm. Therefore, it may be concluded that increasing water depth at the time of mechanical transplanting reduced number of productive tillers. These results are in line with Singh et al (1985). The morphological cause of yield reductions in rice crop under partial submergence has been attributed to impaired tillering (Yoshida, 1981). Talpur et al. (2013) also concluded that deep water tends to inhibit tillering due to the submerged conditions and reduced leaf area during early rooting stages. This is also agreed by Ohe & Mimoto (1999) and De Datta (1981) that excessive water hampers rooting and decreases tiller productions. Figure 2 shows that maximum average number of tillers (22.91 tillers) were attained when water depth of 2.5 cm was maintained at time of transplanting. The yield as well as number of tillers were reduced on average when water depth was increased or decreased.

3.3 Plant Population (m^{-2})

Results depicted in table 2 and 3 clearly emphasize significant difference for number of plants m-2 observed under all the treatments during both the study years. The maximum number of plants (22.63 plants in average) was found in case of treatment where water depth at transplanting time was 2.5 cm during 2011. The minimum number of plants (16.21 plants in average) were found during 2011 in case where water depth at transplanting time was kept 2.5 cm. The results indicated that number of plants decreased with increase of water depth at transplanting time. The number of plants m-2 were counted three days after transplanting. The reduction in number of plants might be due to excess amount of water at transplanting which might have uprooted a number of plants decreasing recommended plant population i.e. 80,000 per acre, in case of water depth i.e. 5.00 cm at the time of transplanting. The same results were observed during both the years. These results are inconformity with Singh et al (1985), Badr et al (2007) and Morsey E.M. (1990). Figure 2 clearly emphasizes the impact of different water levels on plant population (number of hills per meter square). Maximum average hills m-2 were obtained at 2.5 cm water depth, which significantly reduced at shallower water levels.

3.4 Number of Grains per Panicle

Levels of water depth at the time of transplanting, used in this study, showed significant impacts on number of fertile grains per panicle during both the years (Table-2 and 3). Results showed that during 2011 (Table-3) 2.5 cm water depth at transplanting time produced more number of fertile grains per panicle (113.26 grains). Whilst the other three treatments produced significantly less number of fertile grains per panicle. The least number of grains (105.89 grains) per panicle were obtained in case of 7.5 cm water depth at transplanting. The results are similar to those Badr et al (2007) and Ved Parahash et al (2003). Figure 4 clearly depicts the impact of water level on rice production in terms of number of grains per panicle at the time of rice transplanting. The figure shows that maximum number of tillers per panicle were produced at 2.5 cm water depth level. Further increase in water depth drastically reduced yield as well as number of productive tillers during both the years.

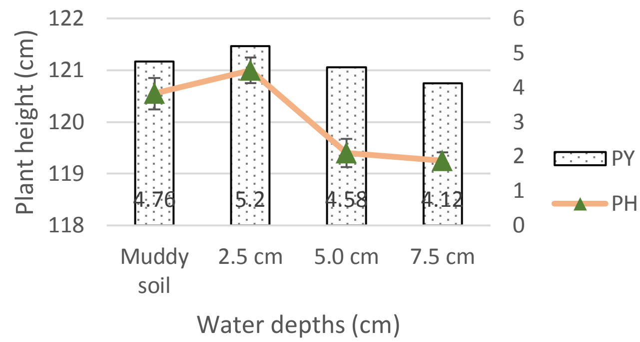

Figure 1: Comparison of effects of different water depth levels on yield (t/ha) in terms of plant height

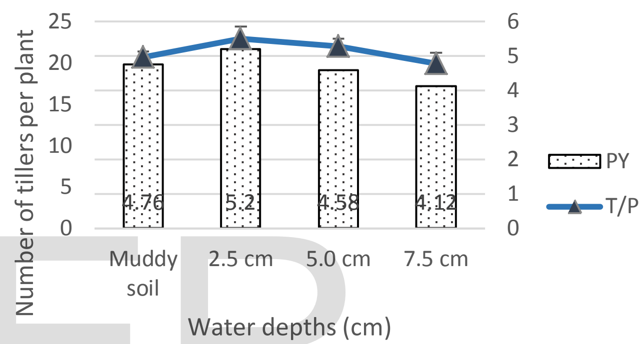

Figure 2: Comparison of effects of different water depth levels on yield (t/ha) in terms of number of tillers per plant

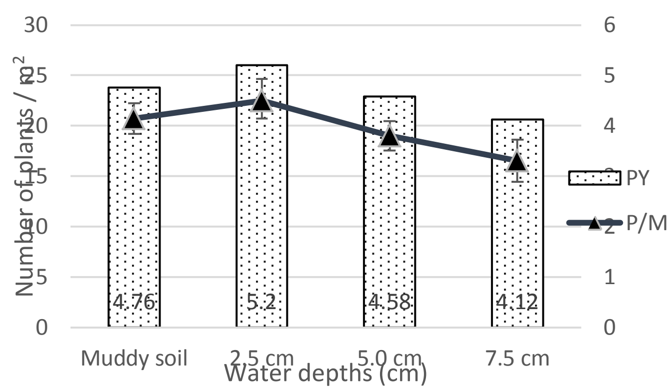

Figure 3: Comparison of effects of different water depth levels on yield (t/ha) in terms of number of plants per meter square

3.5 Thousand Grain Weight (gm)

The results (Table 2 & 3) indicated that there was no significant difference regarding grain weight among different treatments under study. This may be due to that different water depths at transplanting time had effect only on plant population per acre but not on grain weight. Figure 5 shows that maximum weight of 1000 grains was obtained at 2.5 cm water depth level, as compared to other treatments. However, there

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was non-significant difference among the treatments regarding 1000 grain weights during both the years (2010 and 2011).

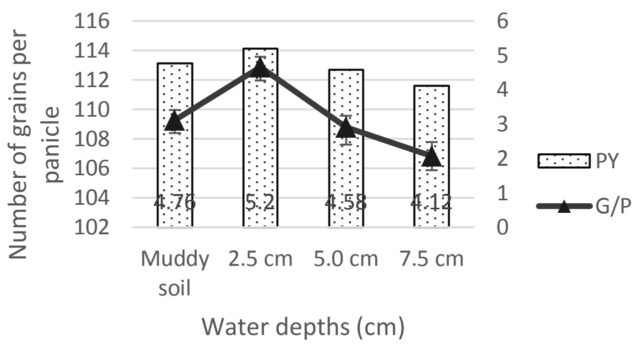

Figure 2: Comparison of effects of different water depth levels on yield (t/ha) in terms of number of grains per panicle

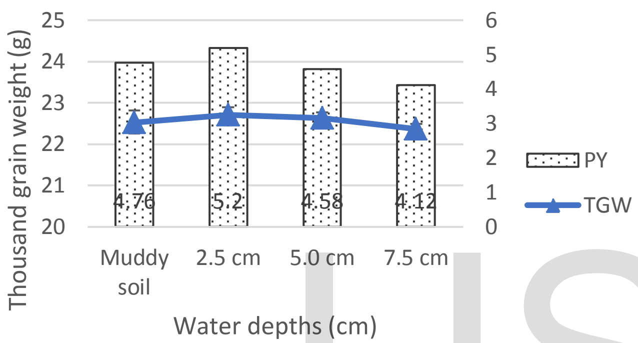

Figure 3: Comparison of effects of different water depth levels on yield (t/ha) in terms of thousand grain weight

3.6 Paddy Yield (t/ha)

The results (Table 2 & 3) indicated that paddy yield of different treatments varied significantly. The maximum paddy yield (5.23 t/ha) was obtained when water depth at transplanting time was maintained 2.50 cm (2010) whereas minimum paddy yield (4.61 t/ha) was found where water depth at time of transplanting was kept 7.50 cm. The similar yield trends were found during 2011. However, paddy yield was slightly low (4.12 t/ha) in case where water depth was 7.50 cm at transplanting time. The same results were also concluded by Ved Prahash Chaudhary & Varshney (2003), Badr et al (2007) and Goel et al (2008) while studying impacts of different levels of water depths on rice crop at different growth stages.

4 Conclusion

The results indicated that maximum paddy yield (5.20 t/ha) was obtained where water depth at transplanting time was maintained at 2.5 cm followed by transplanting in 5.0 cm water depth where the paddy yield was 4.76 t/ha. The minimum paddy yield (4.12 t/ha) was obtained where 7.5 cm water depth at transplanting time was maintained. Surplus or more than required water at transplanting time resulted in reduced growth and significantly decreased the number of missing hills m-2 which ultimately reduced the required number of plant population per acre. It was estimated that increased water depth (7.5 cm) at transplanting time decreased paddy yield by 26.2 %. However, in case of transplanting at 2.5 cm water level, maximum yield was obtained primarily due to highest number of hills per meter square, followed by increased number of productive tillers per plant and number of fertile grains per panicle.

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TABLE 2

Effects of Different Depths of Water for Rice Transplanting and Effect on Paddy Yield during 2010

Treatments	*Plant Height (cm)*	*Number of plants per m^{-2}*	*Number of tillers per plant*	*Number of grains per panicle*	*1000 grain wt.(g)*	*Paddy yield t / ha*
Mechanized transplanting in muddy soil	120.70	20.14b	21.11	109.80	22.49	*4.65 b*
Mechanized transplanting in 2.5 cm standing water	121.20	22.28a	23.28	112.53	22.83	*5.23 a*
Mechanized transplanting in 5.0 cm standing water	119.10	19.11b	21.54	108.42	22.66	*4.57 b*
Mechanized transplanting in 7.5 cm standing water	118.40	16.21c	18.80	106.74	22.35	*4.61 c*
LSD	*1.01*	*2.07*	*1.89*	*2.91*	*NS*	*0.47*

TABLE 3

Effects of Different Depths of Water for Rice Transplanting and Effect on Paddy Yield during 2011

Treatments	*Plant Height (cm)*	*Number of plants per m^{-2}*	*Number of tillers per plant*	*Number of grains per panicle*	*1000 grain wt.(g)*	*Paddy yield t / ha*
Mechanized transplanting in muddy soil	120.40	21.30 a	20.20 b	108.71 b	22.51	*4.87 a*
Mechanized transplanting in 2.5 cm standing water	120.80	22.63 a	22.55 a	113.26 a	22.76	*5.18 a*
Mechanized transplanting in 5.0 cm standing water	119.30	18.89 b	21.53 a	107.21 b	22.58	*4.43 b*
Mechanized transplanting in 7.5 cm standing water	118.10	16.86 c	18.11 c	105.89 c	22.38	*4.07 c*
LSD	*0.93*	*2.11*	*1.84*	*3.17*	*NS*	*0.45*

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