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Growth and Correlation with Weather Parameters as Affected by Transplanting Time and Different Varieties of Paddy (*Oryza sativa* L.)

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ABSTRACT

Background: Time of planting is the most important factor in influencing the yield of the crop. Performance of genotype entirely depends upon the time of planting. For obtaining higher paddy production study of crop for transplanting time and different varieties concerning weather parameters are very necessary.

Methods: Experiment was laid out in a split-plot design with three replications at Agriculture Research Station Farm, Vadgaon-Maval, Tal-Maval, Dist-Pune (M.S.) during *Kharif*, 2013 to study effect of transplanting time on different varieties of paddy concerning weather parameters. 48 treatment combinations were comprised of 4 transplanting times *viz.*, 26th, 28th, 30th and 32nd meteorological weeks and four varieties *viz.*, VDN-3-51-18, VDN-99-29, IET-13549 and RDN-99-1.

Result: Transplanting of *Kharif* paddy during 28th MW improved plant growth. Variety VDN-99-29 recorded significantly higher plant growth. Among the interaction, when the VDN-99-29 variety of paddy was transplanted during 28th MW produced significant effect on plant growth. Correlation indicated that maximum temperature, bright sun hour and growing degree days showed significant and negative co-relationship with plant-growth, minimum temperature, RH-I and RH-II showed positive and significant correlation with growth.

Key words: Correlation, Growth characters, Paddy varieties, Transplanting time, Weather parameters.

INTRODUCTION

Paddy has been the staple food for more than 60 per cent of the world population, providing energy for about 40% of the world population where every third person on earth consumes rice every day in one form or other (Virdia and Mehta, 2009). Therefore, crop paddy (*Oryza sativa* L.) is an important crop that is extensively grown in tropical and subtropical regions of the world. Global demand for food is rising because of population growth, increasing affluence and changing dietary habits. The UN/FAO forecasts that global food production will need to increase by over 40% by 2030 and 70% by 2050. Yet globally, water is anticipated to become scarce and there increasing competition for land, putting added pressure on agricultural production. Besides, climate change will reduce the reliability of the food supply through altered weather patterns and increased pressure from pests and diseases.

Transplanting time and sowing date significantly influenced on growth and yield of rice crops, it has been studied by the number of research workers from various parts of India and abroad. The transplanting time and sowing time of the rice crop are important for three major reasons. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperatures and total sunshine hours. Secondly, the optimum transplanting time and sowing time for each cultivar ensure the cold-sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, transplanting and sowing on-time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved. Results from different studies revealed that the maximum yield potential of a rice crop is usually achieved when the crop is exposed to the most appropriate temperature range, which can be controlled by transplanting sowing at the proper time. Recently weather variability being considered one of the major factors of inter-annual variability of crop growth and yield in all environments besides rainfall, temperature and bright sunshine hours also have been bearing on crop growth and development as well as yield response of different species to different environments can be quite different. The shift in sowing dates directly influences both the thermo and photoperiod and consequently has great impact on the phasic development and partitioning of dry matter (Patel *et al.*, 2019). Timely planting, using proper plant protection measures and providing irrigation at right time was the most desired practices at the farmers own level for yield improvement by rice growers (Grover, 2013).

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The early-planted photoperiod-sensitive rice varieties go through a lag vegetative phase during which increases height, as well as biomass, making them prone to lodging during the grain-filling stage. Adjustment in the transplanting time, therefore, enables the plants to take advantage of natural conditions favourable for growth. Yoshida (1993) reported that rice plants require a particular temperature for phenological responses such as panicle initiation, flowering and panicle exsertion from flag leaf sheath and maturity and these responses are very much influenced by the planting dates in the transplanted paddy. Moreover, the genetic variability and the potentiality of the genotypes were expressed differently due to planting at different dates. The optimum planting time of transplanted *Kharif* paddy is in July but transplanting is sometimes delayed due to various physical and socio-economic factors. Late planting exposes the reproductive phase as well as phonological events of the crop to unfavourable temperature regimes, thereby causing high spikelet sterility and poor plant growth. However, optimum rice planting dates are regional and vary with location and genotypes (Bruns and Abbas, 2006). Chowdhury *et al.* (2000) reported that grain and straw yields gradually decreased when rice is planted after 10th of August transplanting. Islam (1986) concluded that the time between 15 July and 20 August was optimum for transplanting of *Kharif* rice, especially the photosensitive varieties. As the timing of planting influenced the growth and yield of transplanted *Kharif* rice genotypes, the present study was conducted to find optimum transplanting time of four selected high-yielding varieties for the *Kharif* season.

MATERIALS AND METHODS

An experiment entitled, “Effect of transplanting time on different varieties of paddy concerning weather parameters” was carried out in a split-plot with sixteen treatment combinations and three replications. The treatment comprising four transplanting times *viz.*, T_1: 26th MW (24th June to 30th June), T_2: 28th MW (8th July to 14th July), T_3: 30th MW (22nd July to 28th July), T_4: 32nd MW (5th August to 11th August) as main plot treatment and four paddy varieties *viz.*, V_1: VDN-3-51-18 (Indrayani), V_2: VDN-99-29 (Phule Samruddhi), V_3: IET 13549 (Bhogawati), V_4: RDN-99-1 (Phule Radha) as sub-plot treatment during *Kharif*, 2013 at ARS Farm, Vadgaon-Maval, Tal-Maval, Dist-Pune (M.S.), India.

Experimental field soil was clay loam, normal in reaction (pH 7.1), having EC 0.32 dS m^{-1} and OC was medium (0.53%), low in available nitrogen (162.67 kg ha^{-1}), high in available phosphorus (29.56 kg ha^{-1}) and high in available potassium (467.00 kg ha^{-1}). Crop was transplanted according to different treatments of transplanting time along with different varieties. The required quantity of fertilizer was given in the form of Urea-DAP briquette and MOP as basal dose. Gross plot size was 2.95 m × 2.15 m and net plot size was 2.65 m × 1.35 m. Paddy seedlings were raised by line sowing of seeds on the nursery bed. First, second, third and fourth sowing on nursery bed was done on 10th June, 25th June, 9th July and 22nd July, respectively and seedlings were transplanted at 15-25 cm × 15-25 cm spacing. For recording observations, five plants were selected randomly from each net plot and marked by fixing pegs near them. All the observations on growth were recorded on these plants. The statistical analysis of split-plot design with 4 replications, 3 main plot treatments and 3 sub-plot treatments were done by standard procedures suggested by Panse and Sukhamate (1967).

RESULTS AND DISCUSSION

Growth characters of paddy

Plant height of paddy (cm)

Mean plant height was significantly influenced by different transplanting times presented in Table 1. The *Kharif* paddy transplanted during 28th MW has recorded significantly maximum plant height at harvest. This might be due to congenial climatic conditions for better seedling and further

Table 1: Mean plant height (cm) and mean total number of tillers plant^{-1} as influenced periodically by different treatments.

Treatments	Plant height								Number of tillers plant^{-1}
	Days after transplanting (DAT)								
	15	30	45	60	75	90	105	At harvest	At harvest
Main plot: Transplanting times									
T_1: 4th week of June (26th MW)	26.7	42.3	54.9	69.4	79.9	81.2	81.8	82.2	14
T_2: 2nd week of July (28th MW)	27.6	44.1	57.1	72.6	83.5	85.2	85.7	86.2	16
T_3: 4th week of July (30th MW)	23.4	37.4	46.8	60.1	69.1	70.5	70.8	71.3	12
T_4: 2nd week of Aug (32nd MW)	20.9	33.6	42.4	54.2	62.3	63.6	64.0	64.4	8
S.Em±	0.56	0.79	0.77	1.01	1.15	1.11	1.12	1.11	0.28
C.D. at 5%	1.97	2.80	2.73	3.55	4.06	3.93	3.96	3.91	0.84
Subplot: Paddy varieties									
V_1: VDN-3-51-18 (Indrayani)	25.3	40.5	52.3	70.1	80.6	82.2	82.7	83.2	14
V_2: VDN-99-29 (Phule Samruddhi)	28.6	45.8	59.1	73.9	84.9	86.5	87.0	87.5	17
V_3: IET-13549 (Bhogawati)	23.4	37.1	47.9	59.9	69.0	70.4	70.8	71.2	12
V_4: RDN-99-1 (Phule Radha)	21.2	34.1	41.93	52.4	60.3	61.5	61.9	62.2	8
S.Em±	0.44	0.76	1.01	1.23	1.41	1.41	1.41	1.41	0.25
C.D. at 5%	1.29	2.23	2.98	3.60	4.14	4.12	4.15	4.15	1.52
General mean	24.6	39.4	50.3	64.1	73.7	75.1	75.5	76.0	13

Table 2: Mean plant height (cm) and mean total number of tillers plant^{-1} as influenced periodically by interaction between transplanting time and varieties.

Treatment combinations	Plant height								Number of tillers plant^{-1}
	Days after transplanting (DAT)								
	15	30	45	60	75	90	105	At harvest	At harvest
T_1V_1	28.2	45.1	59.1	76.9	88.9	90.2	90.8	91.3	17
T_1V_2	29.1	46.5	61.0	81.2	93.4	95.3	95.8	96.4	17
T_1V_3	23.6	37.8	47.2	65.2	75.0	76.5	77.0	77.4	14
T_1V_4	20.3	32.5	41.7	56.7	65.2	66.5	67.0	67.5	09
T_2V_1	29.7	47.5	62.4	78.0	89.7	90.8	91.3	91.7	19
T_2V_2	32.3	51.6	67.8	84.7	97.4	99.4	100.0	100.6	21
T_2V_3	28.0	44.7	55.9	69.8	80.3	81.9	82.4	82.9	15
T_2V_4	24.5	39.2	50.2	62.7	72.2	73.6	74.1	74.5	11
T_3V_1	25.6	39.6	53.1	66.4	76.4	77.9	78.4	78.9	12
T_3V_2	24.8	39.6	52.6	65.8	75.7	77.2	77.6	78.1	14
T_3V_3	21.5	34.3	41.5	51.9	59.7	60.9	61.3	61.6	10
T_3V_4	27.7	34.7	44.5	55.7	64.0	65.3	65.7	66.1	07
T_4V_1	23.1	36.9	45.0	56.3	64.7	66.0	66.4	66.8	09
T_4V_2	24.2	38.6	46.9	58.6	67.4	68.7	69.2	69.6	11
T_4V_3	20.5	32.7	42.5	53.1	61.1	62.3	62.7	63.1	09
T_4V_4	17.4	27.7	33.2	41.5	47.7	48.7	49.0	49.2	06
S.Em±	1.12	1.58	1.55	2.01	2.30	2.22	2.24	2.21	0.42
C.D. at 5%	3.32	4.62	4.68	6.03	6.65	6.62	6.65	8.58	1.52
General mean	24.6	39.4	50.3	64.1	73.7	75.1	75.5	76.0	13

Table 3: Weekly weather-meteorological data recorded during experiment (June 2013-December 2013).

Month and year	M.W.	Period	Mean Temp. (°C)		R.H. (%)		Rainfall (mm)	Rainy day	Bright sunshine (hrs day^{-1})
			Max.	Min.	Morn.	Eve.			
June-2013	26	24-30	25.8	22.4	91	86	65	7	1.2
July-2013	27	01-07	26.1	22.1	91	87	74	7	1.1
	28	08-14	24.1	21.5	91	91	118	7	1.3
	29	15-21	24.2	21.4	91	91	132	7	1.1
	30	22-28	24.1	21.0	91	91	152	7	0.8
Aug-2013	31	29-04	24.5	21.2	91	88	101	7	1.5
	32	05-11	26.0	22.1	91	84	35	7	2.1
	33	12-18	26.0	21.4	91	84	41	7	1.8
	34	19-25	25.5	21.0	91	81	32	7	1.9
	35	26-01	27.1	21.2	91	83	08	1	5.6
Sept-2013	36	02-08	28.5	20.8	91	83	11	1	3.3
	37	09-15	29.5	21.7	91	74	107	7	1.4
	38	16-22	27.0	21.4	91	83	29	7	1.4
	39	23-29	26.2	21.1	91	84	09	1	2.6
Oct-2013	40	30-06	28.5	21.1	91	72	17	1	1.8
	41	07-13	28.0	19.7	91	75	0	0	7.7
	42	14-20	29.5	21.0	91	67	01	0	8.4
	43	21-27	31.0	19.8	91	81	75	7	4
	44	28-03	30.4	17.5	86	75	0	0	6.6
Nov-2013	45	04-10	30.2	16.8	87	73	0	0	9
	46	11-17	29.7	15.4	83	61	0	0	8.9
	47	18-24	31.4	17.2	90	71	0	0	8.8
	48	25-01	29.5	19.5	90	75	0	0	8
Dec-2013	49	02-08	30.2	16.2	89	70	0	0	8.5

Table 4: Correlation between weather parameters and growth attributing characters.

Weather parameter	Plant height (cm) plant^{-1}							Number of tillers plant^{-1}
	Days after transplanting (DAT)							
	15	30	45	60	75	90	At harvest	At harvest
T max	-0.244	-0.617**	-0.616**	-0.600**	-0.586	-0.604**	-0.601**	-0.630**
T min	0.146	0.114	0.449*	0.241	0.536*	0.574*	0.583*	0.586*
RH-I	0.293	0.276	0.223	0.006	0.153	0.496	0.583*	0.537*
RH-II	0.471*	0.662**	0.637**	0.614**	0.592*	0.598*	0.564*	0.643**
Rainfall	0.362	0.644**	0.643**	0.571*	0.620**	0.599*	0.580*	0.645**
GDD	-0.228	-0.542*	-0.496*	-0.471	-0.023	-0.193	0.304	-0.483
Bright sunshine hr.	-0.619	-0.603**	-0.606**	-0.573*	-0.573*	-0.574*	-0.570*	-0.612**
Canopy temperature	-0.299	0.310	-0.259	-0.255	-0.252	-0.251	-0.250	-0.380

*Significant at 5%; **Significant at 1%.

growth and development of the *Kharif* paddy crop. These results were in accordance with Saikia *et al.* (1989); Paraye and Kandalkar (1994); Rakesh and Sharma (2004) and Dileep *et al*. (2018).

Mean plant height was significantly influenced up to harvesting due to different varieties. The significantly maximum plant height was observed at harvest with the variety Phule Samruddhi (87.5 cm) over the rest of the varieties. This might be due to varietal characters, earlier same reported by Dileep *et al*. (2018); Suryavanshi (2015); Halimi *et al*. (2018) and Shende *et al*. (2020).

Interaction effect between transplanting times and different varieties of paddy was found significant in respect of the mean plant height of paddy shown in Table 2. Variety Phule Samruddhi when transplanted during 28th MW recorded significantly higher plant height at 15 DAT (32.3 cm), 30 DAT (51.6 cm), 45 DAT (67.8 cm), 60 DAT (84.7 cm), 75 DAT (97.4 cm), 90 DAT (99.4 cm), 105 DAT (100 cm) and at harvest (100.6 cm) however it was at par with Indrayani transplanted during 28th MW at all the growth stages except at 30 and 45 DAT as well as with same variety transplanted during 26th MW at 15 and 30 DAT only.

Correlation between weather parameters and plant height

The correlation between parameters with growth characters shown in Table 4 and weekly weather meteorological data recorded during experiment period is presented in Table 3. Paddy variety Phule Samruddhi recorded maximum plant height due to varietal characters and weather conditions during that period.

The correlation between weather parameters and plant height revealed a significant negative correlation in case of maximum temperature from 30 DAT to harvesting, in bright sun hour from 15 DAT to harvesting and in case of GDD 30 DAT to 60 DAT. The highly significant positive correlation found with T min 45 DAT, 60 DAT to at harvest, in RH-I 90 DAT and at harvest, in RH-II from 15 DAT to at harvest and in rainfall from 30 DAT to at harvest. The results found similar to Chandra *et al*. (2009).

Effect on number of tillers plant^{-1}

Number of tillers plant^{-1} was significantly influenced due to different transplanting times at harvest presented in Table 1. The transplanting of paddy seedlings at 28th MW recorded the significantly higher number of tillers (16) over the rest of the transplanting times. The transplanting of paddy at 26th MW performed second-best treatment to produce the significantly higher number of tillers (14) plant^{-1} than 30th MW and 32nd MW. The lowest number of tillers (8) were observed when transplanting was done 32nd MW. These results were in accordance with Rakesh and Sharma (2004), Akram *et al*. (2007); Kabir *et al*. (2014) and Singh *et al*. (2019).

The maximum number of tillers plant^{-1} (17) was found with the variety Phule Samruddhi which was significantly superior over the rest of the paddy varieties. The variety Phule Radha recorded the significantly lower number of tillers plant^{-1} (8) than the remaining varieties. These findings were collaborative with the earlier reported by Suryavanshi (2015), Halimi *et al*. (2018) and Shende *et al*. (2020).

Interaction effects of paddy transplanting times and varieties were significantly influenced number of tillers plant^{-1} shown in Table 2. The transplanting of the variety Phule Samruddhi paddy in 28th MW (2nd week of July) was recorded the highest number of tillers plant^{-1} (21) than the rest of treatment combinations while the lowest in variety Phule Radha in 32nd MW (06).

Correlation between weather parameters and number of tillers plant^{-1}

Correlation between parameters with growth characters presented in Table 4 and weekly weather meteorological data recorded during experiment period is presented in Table 3. The variety Phule Samruddhi recorded the maximum number of tillers plant^{-1} due to varietal characters and weather conditions during that period. The correlation between weather parameters and the number of tillers plant^{-1} revealed the significant negative correlation in the case of maximum temperature (r=-0.630**) and bright sunshine hour (r=0.612**). Significant positive correlation with T min, RH-I, RH-II and rainfall founded r=0.586*, r=0.537*, r=0.643** and r=0.645**, respectively. The results found similar to Chandra *et al*. (2009).

CONCLUSION

Based on experiment findings it was concluded that transplanting time and different paddy varieties significantly

influenced the growth attributing characters of paddy. Transplanting on 28th MW (2nd week of July) resulted significantly maximum in plant height, number of tillers plant^{-1}. The variety Phule Samruddhi recorded significantly higher plant height, number of tillers plant^{-1}, Phule Samruddhi was found suitable under Vadgaon-Maval conditions. Among the interactions, the VDN-99-29 (Phule Samruddhi) variety of paddy was transplanted during 28th MW (2nd week of July) favourably influenced growth attributing characters as compared to other interactions formed due to transplanting times and varieties. Transplanting of Phule Samruddhi on 28th MW (2nd Week of July) was found ideal and climatically suitable for Vadgaon-Maval conditions. Correlation indicated that tmax *i.e.,* maximum temperature, bright sun hour and growing degree days (GDD) showed significant and negative co-relationship with growth attributing characters of paddy, whereas tmin *i.e.,* minimum temperature, RH-I and RH-II during the crop growing period showed positive and significant correlation with growth attributing characters of paddy.

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Conflict of interest

The authors of the manuscript affirm that there are no conflicts of interest related to the publication of this research.

Specifically:

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- **Personal interests:** The authors declare that no personal relationships or obligations exist that could potentially bias the research outcomes or their interpretation.
- **Research objectivity:** The design, execution, and analysis of this study were conducted impartially and ethically, with a primary focus on scientific accuracy and transparency.
- **Author contributions:** All authors have made substantial contributions to the conception, design, execution and analysis of this research. They have thoroughly reviewed and approved the final manuscript for submission to the ARCC journals guidelines, ensuring collective accountability for its content.

The authors further declare that all findings and recommendations presented in this manuscript are based solely on the data and analyses conducted during the study, without external influence or bias.

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