The Pharma Innovation Journal 2018; 7(11): 257-262

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(11): 257-262

www.thepharmajournal.com
Received: 13-09-2018
Accepted: 14-10-2018

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Predicting the effect of weather parameters on yield performance of rice varieties (*Oryza sativa* L.) under different planting condition during *kharif* season

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Abstract
A study was conducted to predict the effect of weather parameters on yield performance of rice varieties (*Oryza sativa* L.) under different planting condition during *kharif*, 2016 at the research farm, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar. The impact of weather parameters on rice yield was estimated by correlation analysis.
The experiment was laid out in a Split-Split Plot design in three replications with three establishment methods as main plot, two dates of sowing as sub plots and two varieties as Sub-Sub plot treatments. All the yield attributing characters i.e., number of panicles per m^2, number of grains per panicle and 1000 grain weight (g) were more in puddled transplanting than unpuddled transplanting and direct seeding. The same treatment also produced maximum grain yield (3879 kg ha^{-1}) and harvest index (HI) (61.52). Grain yield showed positive correlation with evaporation (0.840) and bright sunshine hours (BSH) (0.736), negative correlation with minimum temperature (-0.834), rainfall (-0.587), RH maximum (-0.692) and with RH minimum (-0.829) but grain yield did not show any correlation with maximum temperature.

Keywords: Establishment methods, sowing time, variety, growth parameter, yield and correlation

Introduction
Rice is the staple food for more than half of the world's population and a vital nutritional source for rural poor of most of the countries in the world providing 20% of their dietary energy. The demand of rice as staple food for about 3 billion people is expected to increase further with increase in population. The slogan "Rice is life" during International Year of Rice, 2006 reflects the importance of rice as primary source of food. In India it occupies an area of 43.57 m ha with a production of 104.32 mt and average productivity of 2.29 t ha^{-1}. Odisha occupies an area of 3.94 m ha producing 5.88 mt with an average productivity of 1.49 t ha^{-1}. (Directorate of Economics & Statistics, DAC &FW, 2015-16).
Knowledge on the effect of weather variables during crop's growing period on yield is essential to get maximum input efficiency and optimum grain yields from a crop. Rainfall, solar radiation and temperature strongly influence the growth and yield of upland rice (Gupta and O'Tool, 1986) [7].

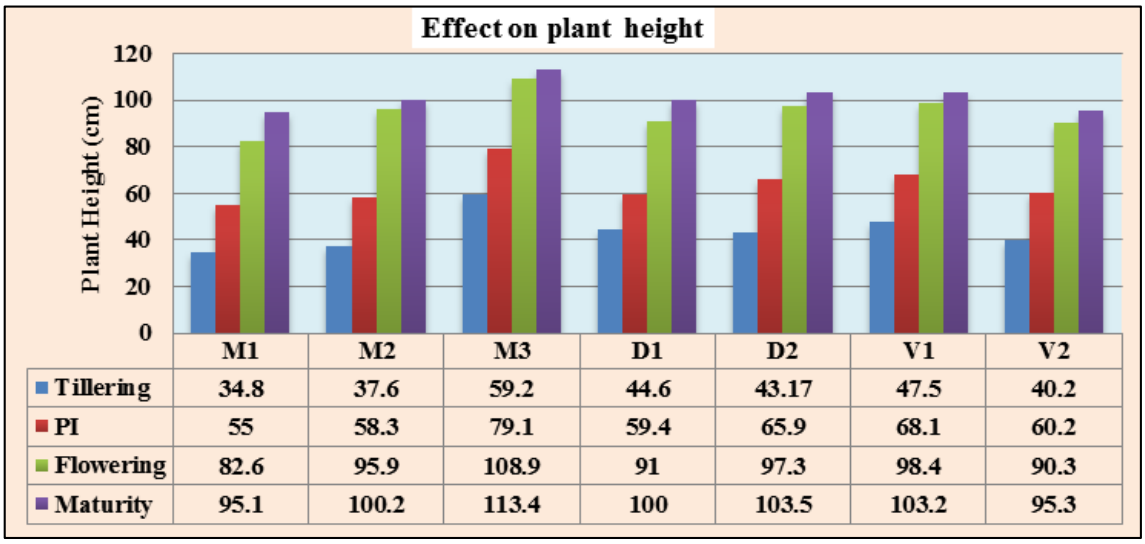
Materials and Methods
A study was conducted to evaluate the effect of weather parameters on yield performance of rice varieties (*Oryza sativa* L.) during *kharif*, 2016 in Split-Split plot design with establishment methods as main plots, dates of sowing as sub plot and varieties as sub-sub plot treatments at research farm, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar. There were 12 treatment combinations consisting of three establishment methods viz., M1- Direct seeded (Line sowing); M2- Transplanting (unpuddled); M3- Transplanting (puddled), two dates of sowing viz., D1– 17th June and D2-26th June and two rice varieties (V1- Naveen, V2 - Pooja) in three replications.
The data was subjected for statistical analysis and coefficient of correlation (r) by using the SAS software. Yield and yield attributes are considered as dependent variables and growth and agro meteorological indices are considered as independent variables.

Results and Discussion

Effects of weather parameters on phenological stages and yield components

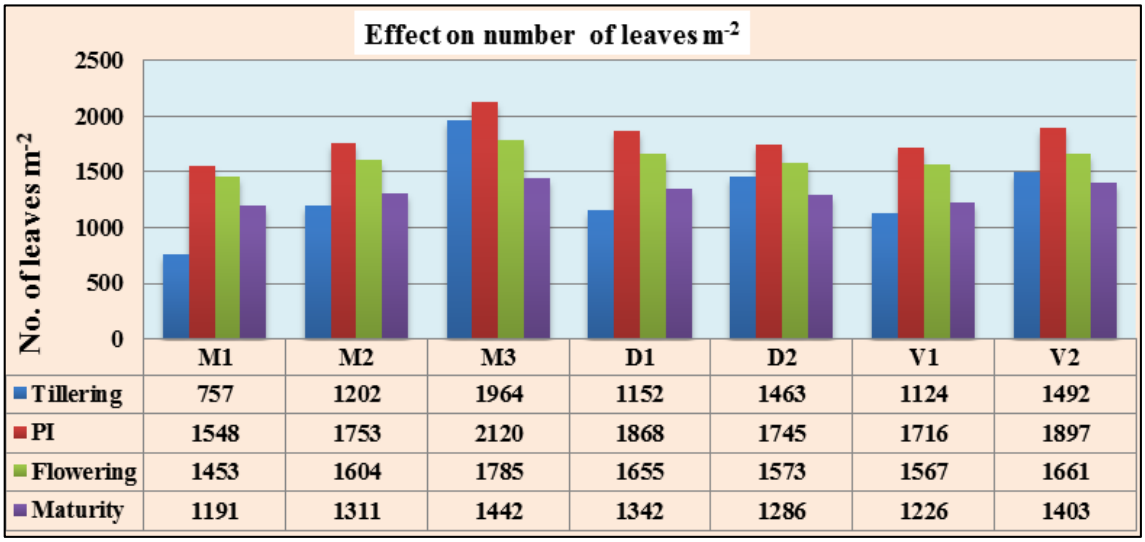
I. Growth Parameters

All the growth parameters viz., plant height, number of leaves per square meter, leaf area index (LAI), number of tillers per square meter and total dry matter per square meter were influenced by rice establishment methods, sowing time and rice genotypes (Fig. 1-5).



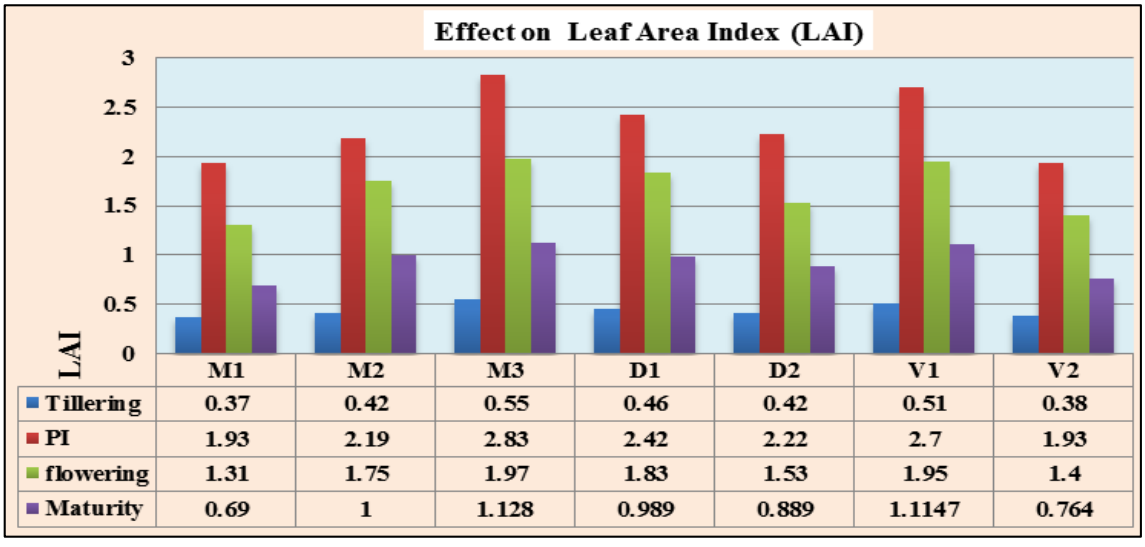
	M1	M2	M3	D1	D2	V1	V2
Tillering	34.8	37.6	59.2	44.6	43.17	47.5	40.2
PI	55	58.3	79.1	59.4	65.9	68.1	60.2
Flowering	82.6	95.9	108.9	91	97.3	98.4	90.3
Maturity	95.1	100.2	113.4	100	103.5	103.2	95.3

Fig 1: Effect of Establishment methods, dates of sowing and variety on plant height



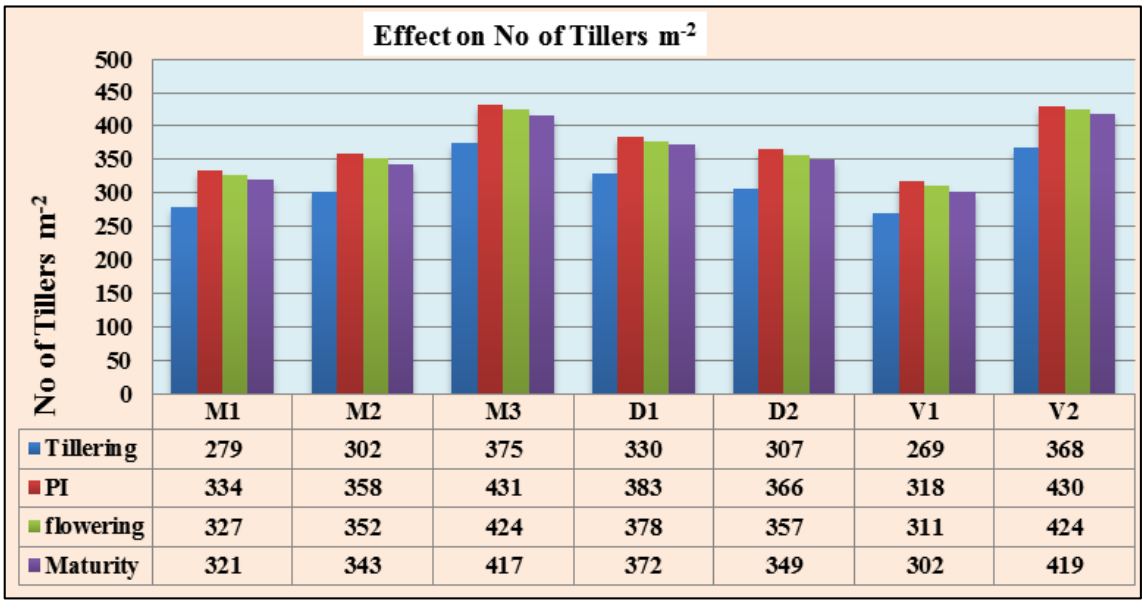
	M1	M2	M3	D1	D2	V1	V2
Tillering	757	1202	1964	1152	1463	1124	1492
PI	1548	1753	2120	1868	1745	1716	1897
Flowering	1453	1604	1785	1655	1573	1567	1661
Maturity	1191	1311	1442	1342	1286	1226	1403

Fig 2: Effect of Establishment methods, dates of sowing and variety on number of leaves per m^2



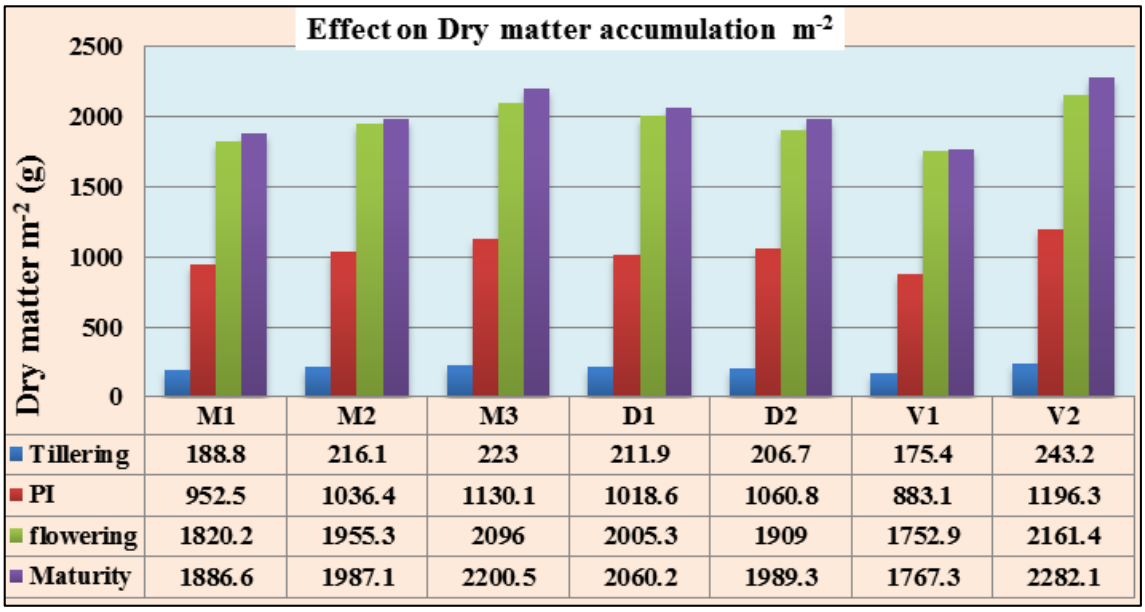
	M1	M2	M3	D1	D2	V1	V2
Tillering	0.37	0.42	0.55	0.46	0.42	0.51	0.38
PI	1.93	2.19	2.83	2.42	2.22	2.7	1.93
flowering	1.31	1.75	1.97	1.83	1.53	1.95	1.4
Maturity	0.69	1	1.128	0.989	0.889	1.1147	0.764

Fig 3: Effect of Establishment methods, dates of sowing and variety on Leaf Area Index (LAI)



	M1	M2	M3	D1	D2	V1	V2
Tillering	279	302	375	330	307	269	368
PI	334	358	431	383	366	318	430
flowering	327	352	424	378	357	311	424
Maturity	321	343	417	372	349	302	419

Fig 4: Effect of Establishment methods, dates of sowing and variety on number of tillers per m^2



	M1	M2	M3	D1	D2	V1	V2
Tillering	188.8	216.1	223	211.9	206.7	175.4	243.2
PI	952.5	1036.4	1130.1	1018.6	1060.8	883.1	1196.3
flowering	1820.2	1955.3	2096	2005.3	1909	1752.9	2161.4
Maturity	1886.6	1987.1	2200.5	2060.2	1989.3	1767.3	2282.1

Fig.5: Effect of Establishment methods, dates of sowing and variety on total dry matter per m^2

Tallest plants were observed in M3 (113.4 cm) at maturity stage, and the variety Naveen (103.2 cm) was tallest throughout the growth stages. Crop sown on D2 (103.5 cm) was taller and the interaction effects among these treatments were non-significant. Similarly, Aslam *et al.* (2008) [1]. And Birhane *et al.* (2013) [3]. Reported that conventionally transplanted crop was taller than direct seeded crop.

Significant differences for number of green leaves per square meter were observed in different planting methods, dates of planting and rice genotypes, but the interaction effects among these treatments were non-significant for this trait.

Total number of green leaves per square meter at panicle initiation stage were maximum in M3 (2120), D1 (1868) and V2 (1897).

Among the three different planting methods maximum leaf area index (LAI) was observed in M3 (2.83) than other two methods. Similar results were also reported by Baloach *et al.* (2006) in rice. Whereas, in the varieties LAI was highest in V2 (2.70) and lowest in V1 (1.93), while in date of sowing it was maximum at D1 (2.42) compared to D2 (2.22).

Maximum number of tillers were observed in M3 (431) as compared to M2 (358) and M1 (334) at all the crop growth stages. Similarly, in dates of sowing it was more in D1 (383) than D2, whereas in varieties Pooja produced more number of tillers (430) than Naveen. Similar results were reported by Birhane (2013) [3] In rice.

Dry matter accumulation was maximum in M3 (2200.5 g) and minimum in M1 (1886.6 g). Whereas, in the varieties it was highest in Pooja (2282.1 g) than Naveen (1767.3 g). Further, in the dates of planting D1 (2060.2 g) registered highest dry matter production compared to D2. The interaction effects among these treatments for this trait was non-significant. The increase in dry matter up to maturity was also reported by AICRPAM, 1997.

II. Yield and Yield Parameters

The results revealed that, the yield parameters viz., number of panicles per square meter, number of filled grains per square meter, test weight (g) (1000 grain weight), grain yield (kg/ha), straw yield (kg/ha) and harvest index (%) were influenced by rice establishment methods, sowing time and genotypes used (Fig. 6-8).

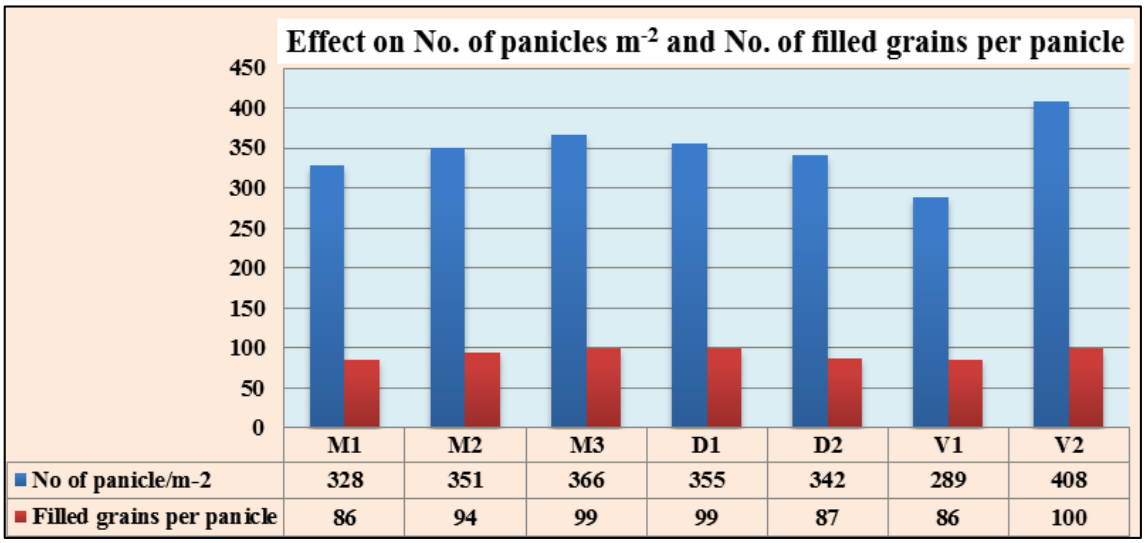


Fig 6: Effect of Establishment methods, dates of sowing and variety on number of panicles per m^2 and number of filled grains per panicle

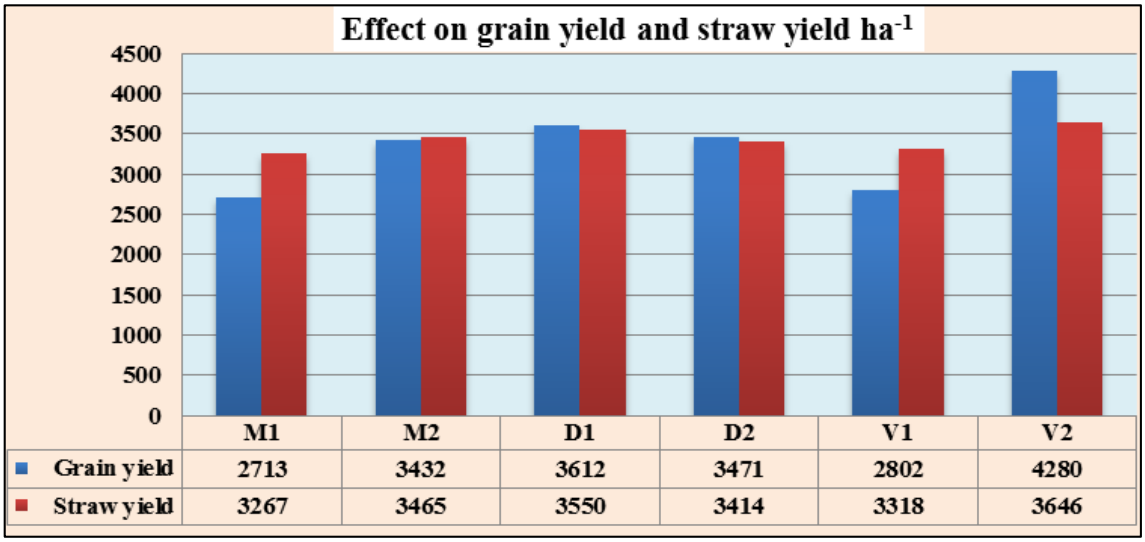


Fig 7: Effect of Establishment methods, dates of sowing and variety on Grain and Straw yield ha^{-1}

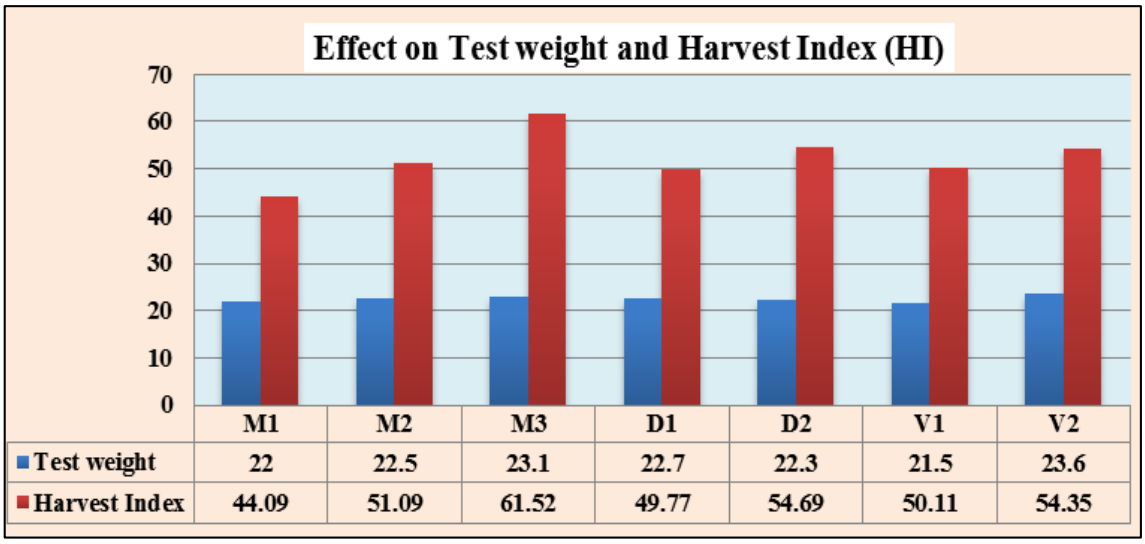


Fig 8: Effect of Establishment methods, dates of sowing and variety on Test weight (1000 grain weight) and Harvest Index (HI)

Maximum numbers of panicles were recorded in M3 (366) than other methods. Similar results were obtained by Baloch *et al*. (2006) in rice and he reported that planting methods had pronounced effect on number of panicles. Whereas, in dates of sowing D1 (355) and variety V2 (408) registered more number of panicles. Back *et al*. (1998) [2]. reported that panicle and spikelet numbers per m^2 were greater in early sowing.

Early planting produced more number of filled grains (99) per panicle than late planting (88). Yuan Ji Chao *et al*. (2004) [10].

Reported the influence of sowing dates on the grain filling in rice. The variety Pooja has more grains per panicle (100) than Naveen (86). The test weight was highest (23.1 g) in M3, D1 and V1 (23.6 g) compared to the other treatments.

The grain yield of rice is a function of total number of panicles, number of grains per panicle and grain weight, which were significantly influenced by the planting methods, dates of sowing and rice cultivars.

Among the three planting methods, M3 registered maximum grain yield of 3879 kg/ha, which was almost 11.5% more than M2 (3432 kg/ha) and 30.05% more than M1 (2713 kg/ha). The early sown crop produced maximum grain yield (3612 kg/ha) than late sown crop (3471 kg/ha). The superiority of early planting on grain yield was also reported by Mukesh *et al*, (2013) [6]. In rice. The highest grain yield was obtained from Pooja (4280 kg/ha), which was almost 34.53% higher than Naveen (2802 kg/ha).

Maximum straw yield was recorded in M3 (3714 kg/ha) followed by M2 (3465 kg/ha) and M1 (3267 kg/ha). The early sown crop registered more straw yield (3550 kg/ha) than late sown crop (3414 kg/ha) and the variety Pooja (3646 kg/ha) produced almost 9% higher straw yield than Naveen (3318 kg/ha).

The harvest index was maximum in M3 (61.5%) followed by M2 (51.09%) and M1 (44.09%). In dates of sowing D2 (54.6%) registered more harvest index than that of D1 (49.7%). Among rice varieties, Pooja (54.3%) recorded highest harvest index than Naveen (50.1%). Similar findings were also reported by Hossain *et al*. (1998) and Salahuddin *et al*. (2009) [8] In rice.

III. Correlation studies

The correlation data revealed that, T max was negatively significant at 5% significance with dry matter (-0.574), whereas T min was positively significant with number of tillers (0.585) at 5% significance and negatively significant with number of panicles (-0.799) and grain yield (-0.834) at 1% significance (Table. 2). Rainfall was negatively significant with number of panicles (-0.805) and grain yield (-0.825) at 1% significance and with test weight (-0.587) at 5% significance. RH max was negatively significant with number of panicles (-0.789) at 1% significance and with grain yield (-0.692) at 5% significance. RH min was negatively significant with number of panicles (-0.776) and grain yield (-0.829). Wind velocity was positively significant with number of panicles (0.891), grain yield (0.866) at 1% significance and with test weight (0.662) at 5% significance. BSH was negatively significant with dry matter (-0.606), positively significant with number of panicles (0.767) and grain yield (0.736) at 1% significance. Evaporation was positively significant with number of panicles (0.841) and grain yield (0.840) at 1% significance.

Table 1: Weekly Weather data of Central Research Farm, OUAT from June 2016 to November 2016

SMW* & Month	Temperature (^{O}C)		Rainfall (mm)	Relative Humidity (%)		Wind velocity (kmph)	BSH (hr)	Evaporation (mm)
	Max.	Min.		07:00 hr	14:00 hr			
23rd (Jun.)	34.1	26.5	66.3	87	74.4	3.6	2.6	5.5
24 (Jun.)	36.1	26.8	24.4	90.6	56.7	6.1	5.9	5.44
25 (Jun.)	33.8	26.3	38.6	88.6	70.6	5.1	7.1	4.93
26 (Jun.- Jul.)	33.4	26.5	99.2	89.3	77.7	4.4	5.7	4.87
27 (Jul.)	32	25.9	83.8	91.7	79.6	5.1	3.4	3.3
28 (Jul.)	30.9	25.8	39	90.9	82	3.7	5.2	3.51
29 (Jul.)	33.4	25.7	16	90.4	73.6	4.3	5.6	3.53
30 (Jul.)	31.9	25.5	67.6	94.4	81.1	4.2	5.8	3.29
31 (Jul. -Aug.)	31.7	25.1	122.5	94.1	84.1	3	4.1	3.32
32 (Aug.)	29.6	25.2	41	96.7	84.6	4	4.2	3.03
33 (Aug.)	31.7	25.3	36.7	93.7	76.3	4.7	4	3.52
34(Aug.)	33.3	25.9	36.2	92	72.6	2.9	4	3.61
35(Aug.- Sep.)	32.9	26.1	10.7	90	78.4	2	6.3	3.43
36 (Sep.)	29.2	24.5	58.1	93.7	85	4	0.5	3.27
37 (Sep.)	32.4	25.9	42.4	93.1	73.9	2.2	4.6	3.46
38 (Sep.)	33.2	26.1	31.2	90.3	72.1	2.2	6.5	3.46
39 (Sep.)	31	24.9	90	95.3	86.6	1.9	2.5	3.13
40 (Oct.)	32.1	24.9	39.8	94.6	73.9	2.4	5.9	3.4
41(Oct.)	31.7	23.9	76.2	92.4	71.7	2	5	3.41
42(Oct.)	32.8	21.3	0	84.4	65	2.1	8.3	3.66
43(Oct.)	32.4	20.5	16.8	86.7	61.9	3.1	5.1	3.41
44(Oct.- Nov.)	32.2	22.6	8.6	88.3	65	3.3	7.3	3.5
45 (Nov.)	29.7	17	11.7	92	52.7	2.8	5.6	3.43
46 (Nov.)	30.7	18.3	0	89.4	47.1	1.6	6.8	3.66
Mean / Total	32.2	24.4	1056.8	91.2	72.8	3.4	5.1	3.7

SMW*: Standard Meteorological week

Table 2: Correlation coefficient between growth and weather parameters

	T max	T min	Rainfall	RH max%	RH min%	Wind vel.	BSH	Evaporation
Pl. Ht	-0.283	-0.084	-0.264	-0.087	0.029	0.421	-0.107	-0.007
Tillers	-0.326	0.585*	0.148	0.487	0.518	0.360	-0.508	-0.507
Leaves	-0.126	0.193	-0.019	0.142	0.051	-0.052	-0.080	-0.111
D.M	-0.574*	0.517	0.272	0.525	0.509	0.545	-0.606*	-0.530
LAI	-0.444	0.341	0.231	0.344	0.312	0.349	-0.385	-0.352

>0.570* - 5% significant: >0.708**- 1% significant

Table 3: Correlation coefficient between yield and weather parameters

Yield Attributes	T max	T min	Rainfall	RH max%	RH min%	Wind velocity	BSH	Evapo
Panicles	-0.156	-0.799**	-0.805**	-0.789**	-0.776**	0.891**	0.767**	0.841**
Fertile Grains	-0.117	-0.351	-0.412	-0.336	-0.347	0.433	0.291	0.377
Grain Yield	-0.265	-0.834**	-0.825**	-0.692*	-0.829**	0.866**	0.736**	0.840**
Straw Yield	-0.159	-0.364	-0.372	-0.319	-0.373	0.460	0.271	0.390
H.I	-0.400	-0.336	-0.050	-0.054	-0.384	0.177	0.138	0.339
Test Wt.	-0.091	-0.501	-0.587*	-0.510	-0.489	0.662*	0.454	0.541

>0.570* - 5% significant; >0.708**- 1% significant

Conclusion

Based on the experimental findings it was concluded that, growth and yield parameters as well as total grain yield was more in puddled transplanted rice crop than unpadded transplanted and direct seeded methods during *kharif*, 2016. Whereas, in dates of planting, early planting of rice (First fortnight of June) gave better yield than late plantings (Second fortnight of June). In case of the varieties tested, Pooja is dwarf in stature, which is desirable character, to prevent lodging and also gave higher yield than Naveen. The maximum temperature, which is an important weather parameter has no impact on rice yield, however, wind velocity, BSH, evaporation minimum temperature, Rainfall, RH max and RH min showed effect on grain yield of rice under *kharif*, 2016 planting conditions in coastal plain zone of Odisha.

Acknowledgement

My deep gratitude and respect to Humble Vice Chancellor, OUAT, Bhubaneswar and the Agro meteorologist, AICRPAM, Department of Agricultural Meteorology, OUAT, Bhubaneswar for their cooperation and guidance during the research work.

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