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Response of Rainfed Upland Rice to Different Drought Management Practices

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Abstract: *A field experiment was conducted to study the effect of date of sowing ,variety and drought management practices in upland rice conditions. The experiment was laid out in split-plot design for rice with three replications at the Central Research Station, OUAT, Bhubaneswar during June 2012 to January 2013. Four combinations of two dates of sowing (18 June and 4 July) and two early maturing (80-95 days) rice varieties (ZHU-XI-26 and Vandana) were allotted to the main-plots and five drought management practices(Broadcasting of non treated seeds, Line sowing 4% KCl treated seeds or non treated seeds, Line sowing 4% KCl treated seeds or non treated seeds with 1/4 of N and K out of recommended dose was top dressed after dry spell) in rice to the sub plots. Grain yield of rice was reduced by 20.8% delayed sowing by 16 days from 18 June to 4 July. The rice varieties experienced two dry spells of 8 days duration each coinciding with sowing to panicle initiation alone or along with sowing to flowering stages.Grain yield of rice was reduced by 20.8 per cent and straw yield by 12 per cent due to delayed sowing by 16 days from 18 June to 4 July. Rice crop variety ZHU-XI-26 produced 32 per cent higher grain yield and 16 percent more straw yield and removed higher amount of primary nutrients than cv. Vandana.*

INTRODUCTION

Rice (*Oryza sativa* L) is a major food of the world and more than half of the population subsists on it, hence called as “Global Grain”. It is the main livelihood of rural population living in subtropical and tropical Asia and hundreds of millions people living in Africa and Latin America. It contains a number of energy rich compounds such as carbohydrates, fat, protein and reasonable amount of iron, calcium, thiamine, riboflavin and niacin (Juliano, 1993). In India it is grown over an area of 44.1 m ha with a total production of of 105m t and a productivity of 2393 kg/ha(CMIE,2012). A number of factors like soil moisture stress, delayed sowing, heavy weed infestation, poor native soil fertility status and poor spread of improved upland cultivars have been identified as important constraints in realization of enhanced productivity levels under rainfed upland situations (Mishra, 1999).

The defining feature of rain fed upland rice ecosystem is the lack of ponded water at any time during the life cycle, so soils remain aerobic throughout where establishment of rice is risky (Wade, 2003). The major problems limiting productivity of upland rice are moisture stress, weed infestation and nutrient deficiency (IRCN, 1985). Among these, drought induced moisture stress has been identified as the major yield depressant of upland rice crop in Eastern India which constitutes about 85% of total upland rice area in India (Widawsky and O’Toole, 1996). About 70% of upland rice area in India are drought prone (Singh, 2002). Productivity of the crop fluctuates drastically from year to year due to vagaries of south-west monsoon, occurrence of dry spells and moisture deficit during growing season. Occurrence of dry spell of varying intensity at different growth stages of upland rice resulting in even complete failure is not uncommon. But the ill effects of

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drought is not equal throughout the life cycle of the plant. Reproductive development of rice is known to be highly vulnerable to water deficit (Saini and Westgate, 2000). Keeping in view the nature of crop, soil and weather conditions, various crop management practices can be integrated together to minimize the adverse effect of moisture stress on upland rice.

Manipulation of sowing time may help the crop to avoid the coincidence of stress at critical period. The crop should be sown in optimum time as that sown too early usually encounters with initial stress, whereas, the delayed sown one suffers much from terminal drought (Behera *et al.*, 1997; Mohapatra *et al.*, 1997).

Most the upland rice soil are deficient in nitrogen. Moisture deficit in upland conditions also prevents rice plant from making full use of applied nitrogen. On the other hand, crop fertilized with over does of N suffers more from moisture stress than that with normal dose. Split application of potassium is beneficial in leaching prone upland soils which may help plants to tolerate stress because of its osmoregulatory property (Das and Zaidi, 2002).

So selection of suitable variety, time and method of sowing, seed treatment and timing of application of nitrogen and potassium may help upland rice crop to alleviate the adverse effect of moisture stress whose occurrence during the copping season is most unpredictable. The present study was therefore conducted to determine the effect of different drought management practices on growth ,yield and yield components of rainfed upland rice.

MATERIALS AND METHODS

Field experiment was carried out during 2012-13 at the Central Research Station, OUAT, Bhubaneswar. The soil of this plot was loamy sand in texture, poor in nutrient content and low in water holding capacity, slightly acidic in reaction (plt-5.20), low in organic carbon (0.36), available in nitrogen (544kg/ha) in available phosphorus (15.60kg/ha), in available potassium (126.70kg/ha). The experiment was conducted in a split-plot design with three replications, four combinations of two early varieties of rice (ZHU-XI-26 and Vandana) sown in two different dates (18 June and 4 July) were allotted to the main plots and five drought management practices (Broadcasting non treated seeds, Line sowing non treated seeds, Line sowing 4% KCl treated seeds, Line sowing non treated seeds but 1/4 of N and K out of recommended dose was top dressed after dry spell, Line sowing 4% KCl treated seeds but 1/4 of N and K out of recommended dose was top dressed after dryspell) in rice sub plots.

Required quantity of seeds as per M3 and M5 treatments were soaked with 4% (analytical grade) solution @1 litre/kg of seeds for 12 hours.The treated seeds were then air dried under shade for five days before sowing. As per the treatments the treated or untreated seeds were sown broadcast or in lines made at 15cm apart. The recommended seed rate of 100kg/ha was used for the experiment.

Recommended fertilizer for upland rice was 40kg N, 20kg P_2O_5 and 20kg K_2O/ha which were applied in the form of urea(46% N), single super phosphate (16% P_2O_5) and murate of potash (60% K_2O),respectively. Nitrogen was applied in three splits i.e., 1/4 as basal, 1/2 at 20 days after sowing (DAS) and 1/4 at panicle initiation (PI) stage. Phosphorous was applied as basal and potassium was applied in two splits i.e., 1/2 basal and 1/2 at PI stage. In M4 and M5 treatment 1/4 out of recommended N and K dose was top dressed after dry spell at 42 and 49 DAS of D_1 and D_2 crops respectively.

Ten plants selected randomly from the net plot area in rice was used for post harvest studies.

RESULTS AND DISCUSSION

Dry matter accumulation by upland rice at different growth stages was not influenced by dates of sowing and varieties up to 45 DAS and by various drought management practices up to 60 DAS. But at 60 DAS, 18 June sown crop produced 14 per cent more DM than 4 July sowing and Vandana rice variety produced 11.5 per cent more than ZHU-XI-26.

Table 1
Effect of date of sowing, variety and drought management practices on plant height (cm) at successive growth stages of upland rice

Particular	*Days after sowing (DAS)*				
	15	*30*	*45*	*60*	*Harvest*
Date of sowing					
18 June	6.37	15.32	28.06	48.44	60.32
4 July	5.79	17.39	29.71	45.29	55.37
SEm±	0.210	0.425	0.630	1.50	1.43
CD(P=0.05)	NS	NS	NS	NS	NS
Variety					
ZHU-XI-26	6.25	16.01	28.11	43.85	51.78
Vandana	5.91	16.69	29.65	49.88	63.91
SEm±	0.210	0.425	0.630	1.50	1.43
CD(P=0.05)	NS	NS	NS	5.18	4.96
Drought management					
M1	5.67	16.45	28.55	46.84	58.04
M2	6.05	16.22	28.42	46.24	57.36
M3	6.18	15.84	28.59	48.43	58.10
M4	6.26	16.56	29.22	46.47	57.80
Ms	6.24	16.69	29.63	46.34	57.94
SEm±	0.219	0.479	0.502	1.10	1.68
CD(P=0.05)	NS	NS	NS	NS	NS

M_1 – Broadcasting non treated seeds
M_2- Line sowing non treated seeds
M_3- Line sowing 4% KCI treated seeds
M_4- M_2 but 1/4 of N and K out of RD topdressed after dry spell
M_5- M_3 but of N and K out of RD top dressed after dry spell

Table 2
Effect of date of sowing, variety and drought management practices on number of tillers per plant at successive growth stages of upland rice

Particular	*Days after sowing*		
	30	*45*	*60*
Date of sowing			
18 June	2.21	3.45	3.83
4 July	1.90	3.70	3.50
SEm±	0.053	0.120	0.110
CD(P=0.05)	0.18	NS	NS
Variety			
ZHU-XI-26	2.17	3.50	3.58
Vandana	1.94	3.65	3.75
SEm±	0.053	0.120	0.110
CD(P=0.05)	0.18	NS	NS
Drought management			
M1	2.01	3.34	3.42
M2	1.93	3.49	3.50
M3	2.09	3.69	3.62
M4	2.09	3.68	3.80
M5	2.15	3.68	3.91
SEm±	0.100	0.180	0.164
CD(P=0.05)	NS	NS	NS

Plant growth and dry matter accumulation

Growth of a plant depends upon its genetic potential as well as the prevailing environmental conditions in which they grow. Crop sown on 18 June and 4 July produced similar dry matter up to 45 DAS. This was due to their similar plant height and tiller number. The data revealed that the average plant height at 15,30,45 and 60 DAS and harvest were 6.1,16.4, 28.9, 46.9 and 57.8cm, respectively. Similarly on an average 2,06,3.58 and 3.67 tillers per plant were produced by upland rice at 30,45 and 60 DAS, respectively (Table 1 and 2). The crops in both the dates were sown with optimum soil moisture condition and were not immediately followed by heavy showers, which could have badly affected seeding vigor (Behera *et al.*, 1997). However the dry matter production by 18 June sown crop was more than 4 July sown crop towards later stages of growth. This was evidenced from lower CGR, RGR and NAR value of 4 July sown crop between 45-60 DAS (Table 5). Tiller number per plant of 4 July sown crop also decreased from 3.7 to 3.5 per plant between 45-60 DAS, whereas that in case of 18 June sown crop increased from 3.45 to 3.83 during the corresponding period (Table 2). Similar was the case for LAI (Table 4). This might be due to receipt of less rainfall coinciding with panicle initiation to maturity stage of 4 July sown crop. The crop also faced both the dry spells during tillering stage.

Total dry matter production by both the varieties were similar up to 45 DAS because of their almost similar plant height, their tiller number, LAI and CGR. But the rice varieties differed significantly in their LAI values at later stages i.e., 60 DAS when LAI of Vandana was 4.44 as against 3.47 of ZHU-XI-26.Similarly between 45 to 60 DAS, CGR of Vandana was 14.66 $g/d/m^2$ as compared to 11.82 $g/d/m^2$ by ZHU-XI-26. Also the dry matter production by the semi tall cv. Vandana was 11.5% higher than the semi dwarf cv. ZHU-XI-26 towards later part of growth (60DAS onwards) coinciding with their panicle emergence stage. This was due to significant increase in plant height, LAI and CGR of the former. However the RGR NAR progressively decreased with advance in growth stages of the crop from 0.1322g/g/m2 at 15-30 DAS to 0.035 at 45-60 DAS and 7.22 g/m2 leaf area/day between 15-30

Table 3
Effect of date of sowing, variety and drought management practices on dry matter accumulation (g/) at successive growth stages of upland rice

Particular	*Days after sowing (DAS)*									
	15	*30*			*45*			*60*		
	Total	*Culm*	*Leaf*	*Total*	*Culm*	*Leaf*	*Total*	*Culm*	*Leaf*	*Total*
Date of sowing										
18 June	14.70	56.02	57.12	113.14	144.12	141.67	285.78	324.29	196.16	520.45
4 July	16.58	55.00	54.25	109.25	149.47	144.20	293.67	294.07	162.09	456.16
SEm±	0.661	2.012	2.487	4.186	3.876	4.971	8.318	7.410	6.533	8.128
CD(P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	25.63	22.60	28.12
Variety										
ZHU-XI-26	15.00	57.95	59.76	117.72	146.42	137.93	284.35	296.22	165.39	461.61
Vandana	16.04	53.08	51.60	104.68	147.17	147.93	295.10	322.14	192.86	515.00
SEm±	0.661	2.012	2.487	4.186	3.876	4.971	8.318	7.410	6.533	8.128
CD(P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	25.63	22.60	28.12
Drought management										
M1	16.51	52.70	55.72	108.42	138.13	129.33	267.46	297.20	164.25	461.45
M2	15.27	57.33	57.04	114.37	143.00	145.83	288.83	314.48	175.13	489.62
M3	17.05	56.18	55.53	111.63	151.83	145.50	297.33	320.43	186.61	507.04
M4	14.03	56.48	53.46	109.93	148.67	148.32	297.00	313.23	185.78	499.01
M5	14.49	54.97	56.67	111.63	152.33	145.67	298.00	300.55	183.84	484.40
SEm±	0.822	3.003	2.649	5.083	6.884	5.393	10.420	9.860	5.958	11.182
CD(P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4
Effect of date of sowing, variety and drought management practices on LAI at successive growth stages of upland rice

Particular	*Days after sowing*			
	15	*30*	*45*	*60*
Date of sowing				
18 June	0.401	2.21	3.45	3.83
4 July	0.461	1.90	3.70	3.50
SEm±	0.018	0.053	0.120	0.110
CD(P=0.05)	NS	0.18	NS	NS
Variety				
ZHU-XI-26	0.413	1.721	3.421	3.473
Vandana	0.449	1.497	3.772	4.436
SEm±	0.018	0.072	0.125	0.149
CD(P=0.05)	NS	NS	NS	0.517
Drought management				
M1	0.458	1.610	3.257	3.628
M2	0.424	1.648	3.666	3.868
M3	0.473	1.605	3.662	4.117
M4	0.397	1.544	3.731	4.103
M5	0.402	1.637	3.667	4.057
SEm±	0.023	0.076	0.150	0.131
CD(P=0.05)	NS	NS	NS	NS

Table 5
Effect of date of sowing, variety and drought management practices on CGR, RGR and NAR at successive growth stages of upland rice

Particular	*CGR (g/d/m)*			*RGR (g/d/m)*			*NAR (g/ leaf area/d)*		
	Days after sowing								
	15-30	*30-45*	*45-60*	*15-30*	*30-45*	*45-60*	*15-30*	*30-45*	*45-60*
Date of sowing									
18 June	6.578	11.509	15.644	0137	0.062	0.041	7.470	4.650	4.136
4 July	6.178	12.294	10.833	0.127	0.067	0.029	6.980	5.099	2.977
SEm±	0.267	0.649	0.711	0.003	0.003	0.002	0.178	0.229	0.234
CD(P=0.05)	**NS**	**NS**	2.459	**NS**	**NS**	0.007	**NS**	**NS**	0.808
Variety									
ZHU-XI-26	6.847	11.109	11.817	0.138	0.059	0.032	7.525	4.550	3.444
Vandana	5.909	12.695	14.660	0.127	0.069	0.037	6.925	5.198	3.669
SEm±	0.267	0.649	0.711	0.003	0.003	0.002	0.178	0.229	0.234
CD(P=0.05)	0.925	**NS**	2.459	0.011	**NS**	**NS**	**NS**	**NS**	**NS**
Drought management									
M1	6.128	10.602	12.933	0.127	0.061	0.036	6.801	4.577	3.823
M2	6.607	11.631	13.386	0.135	0.062	0.035	7.411	4.630	3.577
M3	6.306	12.380	13.980	0.126	0.065	0.036	6.893	5.013	3.704
M4	6.376	12.471	13.467	0.136	0.067	0.035	7.577	5.141	3.463
M5	6.476	12.424	12.427	0.137	0.066	0.032	7.441	5.010	3.214
SEm±	0.355	0.731	1.152	0.005	0.004	0.003	0.348	0.299	0.335
CD(P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 6
Effect of date of sowing, variety and drought management practices on root dry weight (g/) and root volume (cc/) at successive growth stages of upland rice (0-15 cm depth)

Particular	*Days after sowing (DAS)*							
	15		*30*		*45*		*60*	
	Weight	*Volume*	*Weight*	*Volume*	*Weight*	*Volume*	*Weight*	*Volume*
Date of sowing								
18 June	10.03	11.01	41.80	43.3	63.41	139.5	91.01	183.7
4 July	10.64	10.80	30.48	38.6	69.47	146.7	75.16	140.5
SEm±	0.410	0.21	0.739	0.801	2.390	3.24	2.698	4.96
CD(P=0.05)	NS	NS	2.556	2.77	NS	NS	9.34	17.17
Variety								
ZHU-XI-26	11.08	12.14	40.01	44.1	75.07	149.7	97.12	177.4
Vandana	9.59	9.67	32.44	37.8	63.81	136.5	69.06	146.8
SEm±	0.410	0.21	0.739	0.80	2.390	3.24	2.698	4.96
CD(P=0.05)	1.42	0.72	2.556	2.77	8.27	11.21	9.34	17.17
Drought management								
M1	11.30	9.91	32.77	36.8	60.82	138.2	77.58	152.4
M2	9.60	10.92	37.46	41.7	71.17	144.1	82.82	159.6
M3	11.40	11.36	37.64	40.1	72.81	145.0	83.49	165.7
M4	10.00	11.10	37.23	43.8	71.48	143.0	85.27	165.8
M5	9.37	11.21	35.80	42.3	70.92	145.2	86.79	167.0
SEm±	0.578	0.18	1.369	1.53	4.091	3.67	4.335	3.97
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 7
Effect of date of sowing, variety and drought management practices on yield attributes of upland rice

Particular	*Ear bearing tillers/*	*Ineffective tillers/m²*	*Length of panicle (cm)*	*Filled spikelets per panicle*	*Sterility percentage*	*1,000 grain weight (g)*
Date of sowing						
18 June	197.6	48.8	23.48	49.99	30.16	22.43
4 July	162.0	40.7	23.10	39.32	37.70	22.34
SEm±	3.74	1.56	0.171	1.760	1.074	0.049
CD(P=0.05)	12.95	5.4	NS	6.09	3.72	NS
Variety						
ZHU-XI-26	198.0	52.4	22.78	49.39	23.37	24.97
Vandana	161.6	37.2	23.80	39.92	44.49	19.81
SEm±	3.74	1.56	0.171	1.760	1.074	0.049
CD(P=0.05)	12.95	5.4	0.59	6.09	3.72	0.17
Drought management						
M1	172.8	42.8	22.81	44.27	33.93	22.59
M2	178.0	46.9	23.56	45.61	33.93	22.37
M3	174.9	42.8	22.88	43.03	34.68	22.37
M4	187.4	44.8	23.94	45.20	33.18	22.29
M5	185.8	46.4	23.26	45.18	33.93	22.33
SEm±	3.41	1.98	0.371	1.866	1.10	0.115
CD(P=0.05)	NS	NS	NS	NS	NS	NS

Table 8
Effect of date of sowing, variety and drought management practices on grain and straw yield and harvest index (HI) of upland rice

Particular	*Yield (kg/ha)*		
	Grain	*Straw*	*Harvest index (%)*
Date of sowing			
18 June	3425	6671	33.87
4 July	2712	5859	31.64
SEm±	56.2	214.9	0.577
CD(P=0.05)	194	743	2.00
Variety			
ZHU-XI-26	3485	6736	34.12
Vandana	2651	5795	31.40
SEm±	562	2149	0.577
CD(P=0.05)	194	743	2.00
Drought management			
M1	3094	6160	33.17
M2	3043	6404	32.20
M3	3061	6313	32.54
M4	3019	6330	32.39
M5	3125	6120	33.48
SEm±	81.7	186.2	0.780
CD(P=0.05)	NS	NS	NS

DAS to 3.56 at 45-60 DAS respectively (Table 5). The growth of cv. Vandana sown on 18 June was so prominent that the plants completely lodged in almost all drought management treatments. Receipt of about 190 mm rain along with high wind velocity of about 7.9 km/h and almost cloudy sky coinciding with flowering stage of the crop (21 to 25) August resulted in lodging of the crop. The root anchorage of the variety was also poor as evidenced from its lesser root weight by 28.8 per cent and root volume by 17.2 per cent than cv. ZHU-XI-26 at 60 DAS (Table 6). However, the crop lodging was not so serious for the same variety sown on 4 July.

Various drought management practices failed to influence the dry matter production of upland rice even if the crops faced two dry spells. Optimum soil moisture at the time of sowing might have nullified the beneficial effects of line sowing and seed hardening for good seeding vigor. Top dressing of N and K following dry spell was effective only in case of cv. ZHU-XI-26 sown on both the dates because 25 per cent of recommended N and K meant for application after dry spell in treatment M_4 and M_5 was applied a week after panicle initiation stage of cv. ZHU-XI-26 when sown on 18 June and 9 days following panicle initiation when sown on 4 July But the treatment was ineffective in case of cv. Vandana when it almost coincided with the common topdressing meant for panicle initiation stage (Table 4), The vegetative growth might not have also been influenced much because the differential treatment of N and K topdressing were imposed after panicle initiation stage. This was further substantiated by the non significant differences in their plant height, tiller number, LAI, CGR, RGR, NAR, root weight and root volume (Table 1,2,3,4,5).

Yield and yield attributes

Yield of a grain crop like rice depends upon number of ear bearing panicles per unit area, grain per panicle and weight of individual grain. Almost all these yield components were influenced significantly due to date of sowing and varieties. However, effects of different drought management practices were not perceptible. The crop sown on 18 June after receipt of 98 mm cumulative rainfall produced 26.3 per cent more grain yield than when sowing was delayed by 16 days to 4 July. The yield declined, on an average, at a rate of 45 kg grain per a day delay in sowing beyond 18 June (following *Rajo Sankranti*). This might be due to significant decrease in ear bearing tillers by 36/ and number of filled spikelets per panicle by 10 in number due to delayed sowing. Straw yield decreased only by 12 per cent due to decrease in almost all growth parameters towards the later stage. Several workers (Behera et al., 1997; Kebede, 2000; Khatua, 2002) have also reported decrease in grain yield of upland rice due to late sowing. Pravakar and Reddy (1997) have also opined that to create high source capacity it is necessary to sows upland rice crop on or before onset of monsoon. Early sowing of rice usually ensures better utilization of soil nitrogen made available with first shower of rain, good seeding vigour, increase effectiveness of rainfall, adequate weed control and escape to terminal drought. The sterility percentage of spikelets increased to about 38 per cent with delayed sowing. Increased sterility of spikelets due to delayed sowing has also been reported earlier (Pravaker and Reddy, 1997; Kebede, 2000; Khatua, 2002).

Rice variety ZHU-XI-26 produced 31 per cent more grain(3485kg/ha) and 16 per cent higher straw yield(6736 kg/ha) than cv. Vandana(grain yield-2651kg/ha and straw yield-5795 kg/ha). The ear bearing tillers/ (198), fiiled spikelets/panicle (49.4) and 1,000 grain weight (25.0g) of cv. ZHU-XI-26 were respectively, 22.5, 23.7 and 26.0 per cent higher than those of cv. Vandana. Similarly, rice variety ZHU-XI-26 showed higher harvest index (34.1%) than Vandana (31.4%). Sterility percentage of spikelets of the later was 44.5% which is about two times more than that of cv. ZHU-XI-26(23.4%) inspite of its higher dry matter production and growth rate towards later stage. This might be due to severe lodging of cv. Vandana sown on 18 June. Total rainfall from panicle initiation to maturity of the same variety sown on 4 July (339mm) was even less than half of the amount received by cv. ZHU-XI-26 sown on same date (695mm), though, as per our criteria of minimum five days continuous rainless period for a dry spell to occur was not fulfilled during this period.

Various drought management practices failed to influence both grain and straw yield of the upland rice because of their similar effect in all growth parameters and yield attributes for the reasons as stated earlier.

CONCLUSION

Better growth of 18 June sown rice than 4 July sowing was noticed only towards later growth stages. Earlier sown crop produced significantly more number of effevtive tillers (198/) bearing more number of filled spikelets (50) than late sowing on 4 July. Sterility percentage of spikelets increased due to delay in sowing.

The crop sown on 18 June produced 3425 kg grain/ha which was reduced by 20.8 per cent due to delay in sowing by 16 days to 4 July with yield reduction rate of 45 kg grain/ha/day. Sraw yield of late sown crop (5859kg/ha) was about 12 per cent less than early sown one.

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