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PLANT GROWTH CHARACTERS AND PRODUCTIVITY OF TRANSPLANTED HYBRID RICE AS INFLUENCED BY ORGANIC SOURCES AND FERTILIZER LEVELS

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ABSTRACT

An experiment was conducted for two consecutive years at College Farm, College of Agriculture, Rajendranagar during *kharif* 2009 and 2010 to study the effect of organic sources and fertilizer levels on plant growth characters and productivity of hybrid rice. The experiment was laid out in split-plot design with three replications. Among the organic sources, incorporation of subabul @ 5 t/ha recorded the highest plant height, leaf area index, tillers/m^2, dry matter production and grain yield. 200:50 N:K_2O kg/ha was the best fertilizer level and was found significantly superior to remaining fertilizer levels in recording maximum value of plant height, leaf area index, dry matter production, tillers/m^2 and grain yield. Interaction effect between organic sources and fertilizer levels was found significant on dry matter production, tillers/m^2 and grain yield. Subabul incorporation @ 5 t/ha + 200:50 N: K_2O kg/ha recorded the highest dry matter production, tillers/m^2 and grain yield and remained on par with subabul incorporation @ 5 t/ha + 200:25 N: K_2O kg/ha.

Keywords:

Fertilizer levels, Grain yield, Leaf area index, Subabul

INTRODUCTION

Rice (*Oryza sativa* L.) is an important food crop of the world. It is the staple food of the people of South East Asia and at present more than half of the world population subsists on this crop. The success in commercial cultivation of rice hybrids is attributed to their high yield potential which is 15-20% higher over the inbred rice varieties (Jayawardena and Abeysekera, 2005). Agronomic management practice for hybrid rice differs considerably from that of inbred rice varieties. Therefore, to exploit this advantage it is necessary to adopt crop management practices. Nutrient management is one of the most important factors for obtaining higher yields. Inclusion of organic sources along with judicious application of fertilizers is necessary for sustainable agriculture that can ensure food production with high quality. Hence, an investigation was carried out to study the effect of organic sources and fertilizer levels on the growth parameters and grain yield of hybrid rice.

MATERIALS AND METHODS

An experiment was conducted for two years during *kharif* 2009 and 2010 at College Farm, College of Agriculture, Rajendranagar, Hyderabad. The farm is geographically situated at an altitude of 542.6 m MSL, 17º 19' N latitude and 78º 23' E longitudes which falls under the Southern Telangana region of Andhra Pradesh. The soil of the experimental site was sandy clay loam in texture low in available nitrogen (242.3 kg/ha), medium in available phosphorus (39.4 kg/ha) and high in available potassium (368 kg/ha). A total rainfall 511.5 mm was received with 28 rainy days during 2009 and 762.8 mm of rainfall with 49 rainy days during 2010.The experiment was laid out in split plot design with three replications. The treatments consisted of organic sources (control – no organic manuring, subabul incorporation @ 5 t/ha, rice straw incorporation @ 2.5 t/ha) and fertilizer levels comprising of N:K_2O kg/ha (150:75, 175:50, 175:25, 200:50, 200:25, 225:0). Measured quantities of subabul twigs and rice straw were incorporated into the respective treated plot twelve days before transplanting. The % of NPK in subabul twigs was 3.90:0.39:2.2 and 3.84:0.40:2.3 in 2009 and 2010 respectively while in rice straw NPK was recorded as 0.54:0.16:1.6 and 0.51:0.14:1.5 in 2009 and 2010 experimental years, respectively. Nitrogen and potassium were applied as per treatment; P_2O_5 @ 75 kg/ha was uniformly applied to all the plots.

The entire dose of P_2O_5 and half dose of K_2O were applied basally while N was applied in three equal splits *i.e.* at transplanting, maximum tillering and at panicle initiation stage. The remaining K_2O was applied at flowering stage of the crop. Twenty one and twenty five days old seedlings @ one seedling/hill were transplanted during 2009 and 2010 respectively. The hybrid used was 'KRH-2'. Standard cultural practices were followed from transplanting to maturity. Growth characters viz., plant height, leaf area index and tillers/m^2 were recorded at 30, 60, 90 DAT and at harvest of the crop. Dry matter production was recorded at

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harvest. The data was subjected to statistical analysis as outlined by Snedecor and Cochran (1967). Critical difference was calculated at 5% level of probability.

RESULTS AND DISCUSSION

Plant height

The data pertaining to plant height of hybrid rice as influenced by organic sources and fertilizer levels at different crop growth stages is presented in Table 1. In general, the plant height increased with increase in age of crop up to maturity. Plant height was significantly influenced by both organic sources and fertilizer levels at all crop growth stages in both the years. Plant height was significantly higher with subabul incorporation @ 5 t/ha (M_2) followed by rice straw incorporation @ 2.5 t/ha (M_3) during the entire crop growth period in both the years. Both the organic sources were found superior over minerals fertilization (M_1).

The increase in plant height with green leaf manuring might be ascribed to the synchronized N release pattern from the green leaf manure, which has been reported to match well with the N uptake pattern of rice in submerged soils. The results are in line with the findings of Naik (2002). Among fertilizer levels, the increasing levels of nitrogen irrespective of the levels of potassium increased the plant height significantly throughout the period of crop growth. The application of 225:0 N: K_2O kg/ha recorded maximum plant height at all the stages of the crop growth. The lowest plant height was recorded with F_1 (150:75 N: K_2O kg/ha). Higher plant height at higher levels of nitrogen might be due to the association of nitrogen with protoplasm synthesis and elongation of cells extensively along with the main axis leading to longer internodes and height of stem in the presence of higher amounts of nitrogen. The positive effect of nitrogen on the plant height of rice was also reported by Kumar (2009).

Leaf area index

Leaf area represents the measure of photosynthetic efficiency. Leaf area index increased with increase in age of the crop up to 90 DAT and decreased towards maturity. At maturity the rapid translocation of photosynthets to developing sink and mutual shading due to heavy tillering might be responsible for increasing leaf senescence and in turn resulting in lower LAI compared to 90 DAT. Perusal of the data indicated that both sources of organic manures and fertilizer levels significantly influenced the LAI (Table 2). Among organic sources, subabul incorporation @ 5 t/ha (M_2) recorded significantly higher values of LAI over rice straw incorporation @ 2.5 t/ha (M_3) and no organic manuring (M_1) during both the years of study. Both the organic sources were found significantly superior to no organic manuring (M_1). Higher values of LAI associated with subabul green leaf manuring @ 5 t/ha might be due to increased leaf area and production of more number of leaves in this treatment. Similar findings were reported by Naik (2002).

As regards to the influence of different fertilizer levels on leaf area index of hybrid rice, it was found that the fertilizer level F_4 (200:50 N: K_2O kg/ha) recorded the highest LAI values at all stages of crop growth and was found significantly superior over the other fertilizer levels in both the years of study. The benefit of application of high levels of nitrogen was not realized in the absence of K. The advantage of high level application of nitrogen was observed only when an optimum dose (50 kg/ha) of K_2O was applied. This might be due to balanced fertilization of NK at higher levels. The results revealed the importance of balanced fertilization of N and K in maintaining higher LAI values. Kumar (2009) also reported higher LAI values with 200:50 N: K_2O kg/ha.

Tillers/m^2

The effect of organic sources and fertilizer levels on tiller production was significant at all stages of crop growth (Table 3). The tillers/m^2 increased with the increase in age of crop up to 60 DAT and later decreased towards maturity in all the treatments. Subabul incorporation @ 5 t/ha (M_2) resulted in the highest number of tillers when compared to rice straw incorporation @ 2.5 t/ha (M_3) and no organic manuring (M_1) in both the years. Adequate and continuous availability of nutrients through green leaf manuring might be the reason for production of more number of tillers (Naik, 2002; Pramanik *et al*., 2004).

Different levels of fertilizer also significantly influenced the tiller production significantly at all crop growth stages. Among the fertilizer levels, application of 200:50 N: K_2O kg/ha resulted in significantly higher number of tillers/m^2 over the remaining fertilizer levels. The next best treatment was F_5 (200:25 N: K_2O kg/ha). Maximum number of tillers associated with F_4 (200:50 N: K_2O kg/ha) treatment could be ascribed to balanced supply of N and K in this treatment.

The importance of balanced fertilization of nitrogen and potassium in rice was also emphasized by Singh (2004). Interaction effect between organic sources and fertilizer levels was found significant on the number of tillers/m^2 (Tables 4, 5, 6 and 7). Subabul incorporation @ 5 t/ha coupled with 200:50 N: K_2O kg/ha resulted in maximum number of tillers/m^2 throughout the crop growth period during both the years of study and was comparable to M_2F_5 (Subabul incorporation @ 5 t/ha + 200:25 N: K_2O kg/ha).

Table 1: Plant height (cm) of rice as influenced by organic sources and fertilizer levels at different stages of crop growth

Treatment	30 DAT		60 DAT		90 DAT		Harvest	
Organic sources	2009	2010	2009	2010	2009	2010	2009	2010
M_1 - No organic manuring (control)	47.2	48.4	67.5	69.1	82.7	84.7	85.5	86.4
M_2 - Subabul incorporation @ 5 t/ha	51.6	52.8	73.7	75.4	90.2	92.4	93.3	94.3
M_3 - Rice straw incorporation @ 2.5 t/ha	49.5	50.1	70.7	72.3	86.6	88.7	89.5	90.4
CD (*P*=0.05)	1.2	1.0	1.7	1.5	2.1	1.8	3.0	3.3
Fertilizer levels (N:K_2O kg/ha)								
F_1 - 150:75	47.1	48.3	67.4	68.9	82.5	84.4	85.3	86.1
F_2 - 175:50	48.4	49.6	69.2	70.8	84.7	86.7	87.6	88.5
F_3 - 175:25	48.3	49.4	69.0	70.6	84.5	86.5	87.4	88.3
F_4 - 200:50	50.5	51.8	72.2	73.9	88.5	90.6	91.5	92.4
F_5 - 200:25	50.5	51.6	72.1	73.8	88.3	90.4	91.2	92.2
F_6 - 225:0	51.8	53.0	74.0	75.7	90.6	92.7	93.6	94.6
CD (*P*=0.05)	0.4	0.7	0.6	1.0	0.9	1.2	1.9	2.0

Table 2: Leaf area index of rice as influenced by organic sources and fertilizer levels at different stages of crop growth

Treatment	30 DAT		60 DAT		90 DAT		Harvest	
Organic sources	2009	2010	2009	2010	2009	2010	2009	2010
M_1 - No organic manuring (control)	1.89	1.95	3.35	3.45	4.19	4.31	3.14	3.13
M_2 - Subabul incorporation @ 5 t/ha	1.98	2.08	3.64	3.73	4.44	4.68	3.41	3.37
M_3 - Rice straw incorporation @ 2.5 t/ha	1.91	2.01	3.46	3.55	4.27	4.45	3.24	3.27
CD (*P*=0.05)	0.05	0.08	0.21	0.15	0.16	0.20	0.16	0.15
Fertilizer levels (N:K_2O kg/ha)								
F_1 - 150:75	1.88	1.96	3.34	3.45	4.18	4.29	3.13	3.17
F_2 - 175:50	1.92	2.00	3.45	3.55	4.30	4.43	3.23	3.26
F_3 - 175:25	1.88	1.97	3.37	3.45	4.18	4.31	3.16	3.17
F_4 - 200:50	1.98	2.08	3.65	3.77	4.46	4.71	3.42	3.37
F_5 - 200:25	1.96	2.06	3.58	3.66	4.39	4.61	3.36	3.30
F_6 - 225:0	1.92	2.03	3.52	3.58	4.32	4.50	3.29	3.27
CD (*P*=0.05)	0.10	0.10	0.20	0.10	0.18	0.30	0.18	0.20

Table 3: Tillers/m^2 as influenced by organic sources and fertilizer levels at different stages of crop growth in hybrid rice

Treatment	30 DAT		60 DAT		90 DAT		Harvest	
Organic sources	2009	2010	2009	2010	2009	2010	2009	2010
M_1 - No organic manuring (control)	321	372	453	488	319	346	300	323
M_2 - Subabul incorporation @ 5 t/ha	343	397	484	522	340	370	321	345
M_3 - Rice straw incorporation @ 2.5 t/ha	329	381	465	501	327	355	308	332
CD (*P*=0.05)	8	9	11	12	8	9	7	8
Fertilizer levels (N:K_2O kg/ha)								
F_1 - 150:75	319	370	450	486	317	344	298	322
F_2 - 175:50	329	381	465	501	326	355	308	332
F_3 - 175:25	321	372	453	488	318	346	300	323
F_4 - 200:50	345	400	487	525	343	372	322	348
F_5 - 200:25	339	393	478	516	336	366	317	342
F_6 - 225:0	333	385	469	505	330	358	311	335
CD (*P*=0.05)	5	5	6	7	5	5	4	5

Table 4: Effect of interaction between organic sources and fertilizer levels on tillers/m^2 of rice at 30 DAT

Treatment	Fertilizer levels (N:K_2O kg/ha)					
Organic sources	F_1	F_2	F_3	F_4	F_5	F_6
			2009			
M_1- No manuring (Control)	315	325	305	334	324	321
M_2- Subabul incorporation @ 5 t/ha	324	337	336	360	355	347
M_3- Rice straw incorporation @ 2.5 t/ha	319	325	322	342	337	330
	S.Em±			CD (*P*=0.05)		
F at same level of M	4			9		
M at same or different level of F	5			11		
			2010			
M_1- No manuring (Control)	365	377	354	386	376	371
M_2- Subabul incorporation @ 5 t/ha	376	390	389	416	412	401
M_3- Rice straw incorporation @ 2.5 t/ha	369	377	373	397	391	382
	S.Em±			CD (*P*=0.05)		
F at same level of M	4			10		
M at same or different level of F	5			12		

Table 5: Effect of interaction between organic sources and fertilizer levels on tillers/m^2 of rice at 60 DAT

Treatment	Fertilizer levels (N:K_2O kg/ha)					
Organic sources	F_1	F_2	F_3	F_4	F_5	F_6
			2009			
M_1- No manuring (Control)	444	459	430	471	458	453
M_2- Subabul incorporation @ 5 t/ha	458	476	474	507	501	489
M_3- Rice straw incorporation @ 2.5 t/ha	450	459	455	483	476	465
	S.Em±			CD (*P*=0.05)		
F at same level of M	5			13		
M at same or different level of F	6			15		
			2010			
M_1- No manuring (Control)	479	495	465	507	494	488
M_2- Subabul incorporation @ 5 t/ha	494	512	510	547	541	527
M_3- Rice straw incorporation @ 2.5 t/ha	485	495	489	521	513	501
	S.Em±			CD (*P*=0.05)		
M at same or different level of F	7			16		

Dry matter production

The dry matter production is an indication of resource use efficiency. Dry matter production increased with the advancement of crop growth towards maturity. Subabul incorporation @ 5 t/ ha (M_2) significantly increased the dry matter production over rice straw incorporation @ 2.5 t/ha (M_3) and no organic manuring (M_1) treatments in Corresponding growth phases. Significant improvement in dry matter production with green manuring was also reported by Prasad (2000) and Naik (2002). Among the fertilizer levels, application of 200:50 N: K_2O kg/ha resulted in the highest dry matter production and was found significantly superior to other fertilizer levels. The highest dry matter production was recorded by F_4 (200:50 N: K_2O both the years. Rice straw incorporation @ 2.5 t/ha recorded significantly higher dry matter when compared to no organic manuring (control). The increase in dry matter accumulation of hybrid rice in the present investigation in response to incorporation of green leaf manure is the result of cumulative effect of substantial improvement in vegetative and reproductive growth structures during the kg/ha) owing to improved plant stature, more number of tillers and increased leaf area (Table 8).Interaction effect was found significant. The highest dry matter production was recorded by subabul incorporation @ 5 t/ha + 200:50 N: K_2O kg/ha and remained on par with subabul @ 5 t/ha + 200:25 N: K_2O kg/ha during both the years. The next best treatment was M_2F_6 (Table 9).

Table 6: Effect of interaction between organic sources and fertilizer levels on tillers/m^2 of rice at 90 DAT

Treatment	Fertilizer levels (N:K_2O kg/ha)					
Organic sources	F_1	F_2	F_3	F_4	F_5	F_6
			2009			
M_1- No manuring (Control)	315	325	305	334	324	321
M_2- Subabul incorporation @ 5 t/ha	324	337	336	360	355	347
M_3- Rice straw incorporation @ 2.5 t/ha	319	325	322	342	337	330
	S.Em±			CD (P=0.05)		
F at same level of M	4			9		
M at same or different level of F	5			11		
			2010			
M_1- No manuring (Control)	339	351	330	360	350	346
M_2- Subabul incorporation @ 5 t/ha	350	363	362	387	383	373
M_3- Rice straw incorporation @ 2.5 t/ha	343	351	347	369	364	355
	S.Em±			CD (P=0.05)		
F at same level of M	4			10		
M at same or different level of F	5			11		

Table 7 Effect of interaction between organic sources and fertilizer levels on tillers/m^2 of rice at harvest

Treatment	Fertilizer levels (N:K_2O kg/ha)					
Organic sources	F_1	F_2	F_3	F_4	F_5	F_6
			2009			
M_1- No manuring (Control)	294	304	285	312	303	300
M_2- Subabul incorporation @ 5 t/ha	303	315	314	336	332	324
M_3- Rice straw incorporation @ 2.5 t/ a	298	304	301	320	315	308
	S.Em±			CD (*P*=0.05)		
F at same level of M	4			8		
M at same or different level of F	4			10		
			2010			
M_1- No manuring (Control)	317	328	308	336	327	323
M_2- Subabul incorporation @ 5 t/ha	327	339	338	362	358	349
M_3- Rice straw incorporation @ 2.5 t/ha	321	328	324	345	340	332
	S.Em±			CD (*P*=0.05)		
F at same level of M	4			9		
M at same or different level of F	5			11		

Days to 50 percent flowering and physiological maturity

The data on days to 50% flowering and physiological maturity as influenced by organic sources and fertilizer levels is presented in Table 8. The addition of organic manures prolonged the time taken for 50% flowering and physiological maturity by hybrid rice during both the years. The crop increased with incorporation of subabul took maximum number of days to attain 50% flowering and physiological maturity compared to rice straw incorporation and no organic manuring (control). Delay in days to attain 50% flowering and physiological maturity in M_2 (Subabul incorporation @ 5 t/ha) could be ascribed to slow and continuous availability of nitrogen through green leaf manuring. Results corroborate with the findings of Naik (2002). Among the fertilizer levels, application of 225:0 N: K_2O kg/ha (F_6) took maximum number of days to reach 50% flowering. Similar trend was observed with regard to days to physiological maturity. Higher levels of nitrogen prolonged the vegetative growth and might have increased the days to 50% flowering and physiological maturity. The results are in line with the findings of Neelima (2005).

Grain Yield

Incorporation of subabul @ 5 t/ha recorded the highest grain yield followed by rice straw incorporation @ 2.5 t/ha. Both the organic treatments were found significantly superior to control. Incorporation of organic sources might have enhanced the availability of nutrients in soil which in-turn increased the number of tillers and other growth parameters ultimately resulting in higher yields. Nazmus Salahin *et al.* (2013) also reported an increase in grain yield of rice with incorporation of green manures compared to control. Among the fertilizer levels tested,

200:50 N: K_2O kg/ha recorded the highest grain yield. Balanced fertilization of N and K might be the probable reason for obtaining maximum yield in F_4 treatment (Table 8). The interaction effect between organic sources and fertilizer levels was found significant in both the years (Table 10). Incorporation of subabul @ 5 t/ha significantly improved the grain yield at all fertilizer levels except F_1. The additional grain yield obtained with subabul incorporation under F_1 was 96, 164 kg/ha and 100, 170 kg/ha compared to rice straw incorporation and no organic manuring during 2009 and 2010 respectively but the differences were found non-significant. Rice straw incorporation @ 2.5 t/ha augmented the rice grain yields only at fertilizer levels F_3 and F_5 as compared under control. Fertilizer levels F_2 and F_3 (nitrogen constant at 175 kg/ha and potassium at 50 and 25 kg/ha respectively) gave on par grain yields under manure treatments M_2 and M_3. Similarly, fertilizer levels F_4 and F_5 (nitrogen constant at 200 kg/ha and potassium at 50 and 25 kg/ha respectively) gave on par yields indicating that incorporation of organic sources coupled with higher levels of nitrogen could help in reducing the level of potassium application.

Table 8: Dry matter production, days to 50 %, days to physiological maturity and grain yield of rice as influenced by organic sources and fertilizer levels

Treatment	DMP (q/ha) at harvest		Days to 50% flowering		Physiological maturity		Grain yield (kg/ha)	
Organic sources	2009	2010	2009	2010	2009	2010	2009	2010
M_1 - No organic manuring (control)	125.55	128.65	107	107	123	123	5623	5753
M_2 - Subabul incorporation @ 5 t/ha	135.21	138.50	112	113	127	128	6012	6155
M_3 - Rice straw incorporation @ 2.5 t/ha	129.11	132.44	108	108	124	124	5772	5908
CD (*P*=0.05)	2.08	2.39	2.0	1.0	2.0	2.0	123	142
Fertilizer levels (N:K_2O kg/ha)								
F_1 - 150:75	125.14	128.08	107	106	122	122	5597	5730
F_2 - 175:50	129.21	123.24	108	108	123	123	5776	5907
F_3 - 175:25	12.582	128.85	110	110	123	123	5639	5760
F_4 - 200:50	135.81	139.35	111	111	124	125	6041	6190
F_5 - 200:25	133.16	136.62	111	111	124	125	5937	6083
F_6 - 225:0	130.60	133.93	113	114	127	127	5823	5963
CD (*P*=0.05)	0.90	0.87	1.0	1.0	1.0	1.0	85	81

Table 9: Effect of interaction between organic sources and fertilizer levels on dry matter production (q/ha) of rice at harvest

Treatment	Fertilizer levels (N:K_2O kg/ha)					
Organic sources	F_1	F_2	F_3	F_4	F_5	F_6
	2009					
M_1- No manuring (Control)	123.07	127.43	119.36	131.22	126.65	125.56
M_2- Subabul incorporation @ 5 t/ha	127.80	132.71	132.38	141.65	140.13	136.57
M_3- Rice straw incorporation @ 2.5 t/ha	124.55	127.51	125.70	134.58	132.69	129.66
	S.Em±			CD (*P*=0.05)		
F at same level of M	1.24			2.88		
M at same or different level of F	1.03			2.49		
	2010					
M_1- No manuring (Control)	126.15	130.56	122.09	134.37	129.95	128.77
M_2- Subabul incorporation @ 5 t/ha	130.43	135.89	135.41	145.44	143.78	140.06
M_3- Rice straw incorporation @ 2.5 t/ha	127.66	130.56	129.05	138.23	136.14	132.97
	S.Em±			CD (*P*=0.05)		
F at same level of M	0.74			1.84		
M at same or different level of F	1.10			2.73		

CONCLUSION

The maximum yield advantage by both subabul and rice straw incorporation was obtained with F_4 (200:50 N: K_2O kg/ha) and was comparable to F_5 (200:25 N: K_2O kg/ha) thus saving 25 kg K_2O/ha. The highest grain yield was obtained with M_2F_4 and remained on par with M_2F_5. The reduction in grain yield due to either skipping of K fertilizers or application of low doses of K could be compensated when K rich organic sources like subabul and rice straw are coupled with high levels of N application.

Table 10: Effect of interaction between organic sources and fertilizer levels on grain yield (kg/ha) of hybrid rice

Treatment	**Fertilizer levels (N:K_2O kg/ha)**					
Organic sources	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**
			2009			
M_1- No manuring (Control)	5520	5708	5365	5848	5680	5615
M_2- Subabul incorporation @ 5 t/ha	5684	5907	5893	6289	6227	6074
M_3- Rice straw incorporation @ 2.5 t/ha	5588	5712	5659	5987	5905	5781
	S.Em±			CD (*P*=0.05)		
F at same level of M	72			163		
M at same or different level of F	79			180		
			2010			
M_1- No manuring (Control)	5650	5840	5480	5980	5820	5750
M_2- Subabul incorporation @ 5 t/ha	5820	6040	6020	6450	6380	6220
M_3- Rice straw incorporation @ 2.5 t/ha	5720	5840	5780	6140	6050	5920
	S.Em±			CD (*P*=0.05)		
F at same level of M	68			159		
M at same or different level of F	80			188		

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