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Ankita Singh
Acharya Narendra Deva University of Agricultural and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

AK Singh
Acharya Narendra Deva University of Agricultural and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Ankita Singh
Acharya Narendra Deva University of Agricultural and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Response of different zinc level on yield of Sub1 and non Sub1 rice varieties under submerged condition

Ankita Singh and AK Singh

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Abstract
An experiment was conducted to study the effect of zinc sulphate by assessing yield attributes at before and after submerged condition for improving submergence tolerance in Sub1 and non-Sub1 rice varieties. The completely randomized block design was adopted with three treatments, three replications and five rice varieties selected on the basis of submergence tolerance and susceptibility. Seeds were sown in pot directly with the treatments include viz. T1: 0.0 mg ZnSO4 per kg soil, T 2: 5.0 mg ZnSO4 per kg soil, T3: 10 mg ZnSO4 per kg soil. Treatments were done in submerged and non-submerged (controlled) pots both at the time of sowing. After 30 days of sowing, fifteen days of complete submergence was given. From that, it is concluded that zinc sulphate @10 mg/kg soil significantly enhanced yield of Sub1and non-Sub1 rice varieties even after 15 days of complete submergence.

Keywords: Submergence; zinc sulphate; Sub1 and non-Sub1 rice varieties; yield response

Introduction
Rice, *Oryza sativa* L. (2n = 24) is an important crop of the world grown worldwide. It is expected to be most vulnerable cultivated crop to future changing climates (Mohanty *et al*., 2013; Narciso and Hossain, 2002) [5, 7]. It supplies staple food for nearly 50% of theglobal population and influences the livelihoods and economies of several billion people (USDA, 2016) [12]. Rice can grow well in paddy fields (unlike other cereal) and is highly tolerant of excess water stress from submergence (in which part or all of the plant is under water). Rice handles submergence stress by internal aeration and growth controls. Plants require water for growth but excess water that occurs during submergence is harmful or even lethal. A submerged plant is defined as a plant standing in water with at least part of the terminal above the water or completely covered with water (Catling 1992). Submergence subjects plants to the stresses of low light, limited gas diffusion, effusion of soil nutrients, mechanical damage and increased susceptibility to pests and diseases (Ram *et al*. 2002)[10]. Such flood may continue for a week or more inflicting heavy damage to standing crop. As a result yield of rice plant is severely decreased (Lindner 1944) [4]. Complete submergence at the vegetative stage of rice causes deterioration in the plant quality and causes substantial yield loss. Zinc is an important macro-micronutrient which activates many enzymes to carrying out many metabolic reactions for growth and development of crops (Prakash 2019) [8]. Low zinc content in soil reduces yield of crops by stunting its growth, decreasing number of tillers, spikilet sterility (Hafeez *et al* 2013; Sudha and Stalin 2015) [3, 11]. Flood-irrigated rice is more prone to Zn deficiency due to submergence condition (Rahman *et al*., 2012) [9]. By the application of zinc yield of grain can be increased (Vandana and Rajesh 2018). Therefore, based on the above facts, the study was carried out to examine the effects of zinc sulphate on yield different rice cultivars under submergence condition.

Materials and methods
The research was carried at Experimental Farm of Department of Crop Physiology, Archarya Narendra Deva University of Agriculture and Technology, Kumarganj (U.P), India during Kharif season. The experiment was Completely Randomized Block Design with three replications and performed in earthern pots with three different zinc levels and five different varieties of rice

Varieties and treatments detail (Zinc sulphate) taken for study

V1	Swarna
V2	Swarna Sub1
V3	Samba mahsuri
V4	Samba mahsuri Sub1
V5	IR-64 Sub1

Concentration	
T1	0.0 mg ZnSO4 per kg soil
T2	5.0 mg ZnSO4 per kg soil
T3	10.0 mg ZnSO4 per kg soil

The five varieties have been selected on the basis of their submergence tolerance character as Swarna Sub1, Samba mahsuri Sub1, and IR-64 Sub1 are submergence tolerant whereas Swarna, Samba mahsuri are susceptible varieties.
Zinc sulphate was applied in the soil at the time of sowing of seeds in the earthern pots of uniform size (25×20 cm) were used and each pot was filled with 8 kg of well pulverized soil with recommended dose of NPK 120:60:60Kg/ha. Initially five plants were raised in each pot but after thinning three plants were maintained in each pot.

Submergence treatment
The submerged condition was created by submerging pots in the cemented tank and non-submerged plants were remained at the Laboratory Farm. Submerged condition was provided after 30 days old rice seedling. The submergence duration for 15 days created. Observation for yield and its parameter in pot were recorded for character panicle length (cm), ear bearing tiller per pot, panicle weight (g), grain number per panicle, test weight (g), grain yield per plant (g), grain yield per pot (g), biological yield (g) and harvest index (%).

Determination of yield and yield attributes

1. Panicle length (cm)
Length of panicle observed manually in centimeter.

2. Ear bearing tiller (EBT) per pot
The number of ear bearing tiller per pot were counted at maturity.

3. Panicle weight (g)
The panicle weight was recorded ing after harvesting and production were recorded ing by electronic balance.

4. Grain number per panicle
Grains were carefully separated from panicles of plant and number ofgrain per panicle was counted for each treatment.

5. Test weight (1000 seed weight)
1000 seeds from each treatment were counted and weighed for assessing test weight in each treatment.

6. Grain yield per plant (g)
Thegrain yields were recorded ing plant-1 after harvesting and production were recorded ing by electronic balance.

7. Grain yield per pot(g)
Thegrain yield was recorded ing pot-1 after harvesting as there were two plant left in each pot after thinning, thegrains were taken out carefully and weighed by electronic balance.

8. Biological yield (g)
The biological yield was accounted as the total above pot crop dry matter per pot under each treatment.

9. Harvest Index (%)
The ratio ofgrain yield (g) to total dry matter of plant was considered as harvest index and expressed in percentage. It was calculated by the following formula (Donald and Hamblin, 1976).

$$\text{Harvest index (\%)} = \frac{\text{Grain yield per plant (g)}}{\text{Biological yield per plant (g)}} \times 100$$

Statistical analyses
Data recorded on yield attributes were subjected to statistical analysis by Fisher method of analysis of variance (Fisher and Yates 1949).
The significance of various treatments was judged by comparing calculated 'F' value with Fisher's 'F' value at 5 percent level, incorporate in tables, were also calculated to compare the relative performance of various treatments by using the following formula:

$$\text{SEm}\pm = \frac{\text{EMS}}{\text{N}}$$

Where, EMS is mean sum of square of error
N = total number of experimental unit level of factors

$$CD = \sqrt{\frac{2\text{EMS}}{\text{N}}} \times t(\%$$

Where value of 't' from Fisher's table at error degree of freedom on 5% level of significance.

Result
The result regarding panicle length (cm), ear bearing tiller per pot, panicle weight (g),grain number per panicle, grain yield per pot (g), test weight (g),grain yield per pot (g), biological yield (g) and harvest index (%) under submerged condition in different submergence tolerant as well as susceptible varieties on applying different zinc level are as follows:

1. Panicle length (cm)
The data recorded on panicle length due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table 1. The maximum panicle length was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (24.53 cm) & Samba mahsuri (21.66 cm) and for Sub1 varieties i.e. Swarna Sub1 (25.50 cm), Samba mahsuri Sub1 (22.90 cm) & IR64 Sub1 (19.73 cm) in controlled condition, while in submerged condition, maximum panicle length was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (19.96 cm) & Samba mahsuri (26.20 cm) and for Sub1 varieties i.e. Swarna Sub1 (18.95 cm), Samba mahsuri Sub1 (16.86 cm) & IR64 Sub1 (15.73 cm).

2. Ear bearing tiller per pot
The data recorded on number of ear bearing tiller per pot due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table. The maximum number of ear bearing tiller per pot was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e.

Swarna (14.33) & Samba mahsuri (12.0) and for Sub1 varieties i.e. Swarna Sub1 (14.66), Samba mahsuri Sub1 (12.33) & IR64 Sub1 (12.33) in controlled condition, while in submerged condition, maximum number of ear bearing tiller per pot was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (9.66) & Samba mahsuri (10.33) and for Sub1 varieties i.e. Swarna Sub1 (12.0), Samba mahsuri Sub1 (11.66) & IR64 Sub1 (9.66)

Table 1: Effect of zinc sulphate on panicle length (cm) and ear bearing tiller per pot on Sub1 and non-Sub1 rice varieties exposed to 15 days of complete submergence

Treatments / Varieties	Panicle length (cm)						Ear bearing Tiller per pot					
	T1		T2		T3		T1		T2		T3	
	A	B	A	B	A	B	A	B	A	B	A	B
V1	21.43	17.93	22.86	18.90	24.53	19.96	13.0	8.33	13.33	9.33	14.33	9.66
V2	20.53	16.13	22.93	17.63	25.50	18.95	14.0	9.66	14.66	10.66	14.66	12.0
V3	20.20	25.50	20.13	25.63	21.66	26.20	10.66	8.33	11.66	9.33	12.0	10.33
V4	19.66	15.50	21.13	15.86	22.90	16.86	11.0	9.33	12.0	10.66	12.33	11.66
V5	17.73	13.96	18.70	14.83	19.73	15.73	11.33	7.66	12.33	8.0	12.33	9.66

Here, A= Controlled condition B= Submerged condition

	Controlled	Submerged	Controlled	Submerged
SEm±	0.211	0.181	0.243	0.277
L.S.D at 5%	0.610	0.529	0.703	0.801

3. Panicle weight (g)

The data recorded on panicle weight due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table 2. The maximum panicle weight was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (16.09g) & Samba mahsuri (16.30g) and for Sub1 varieties i.e. Swarna Sub1 (17.82g), Samba mahsuri Sub1 (17.37g) & IR64 Sub1 (15.23g) in controlled condition, while in submerged condition, maximum panicle weight was recorded at zinc level @ 10.0 mg/kg soil for non- Sub1 varieties i.e. Swarna (14.65g) & Samba mahsuri (13.44g) and for Sub1 varieties i.e. Swarna Sub1 (12.42g), Samba Mahsuri Sub1 (11.90g) & IR64 Sub1 (9.98g)

4. Grain number per panicle

The data recorded ongrain number per panicle due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table 2. The maximumgrain number per panicle was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (107.0) & Samba mahsuri (140) and for Sub1 varieties i.e. Swarna Sub1 (112.33), Samba mahsuri Sub1 (139.0) & IR64 Sub1 (141.0) in controlled condition, while in submerged condition, maximumgrain number per panicle was recorded at zinc level @ 10.0 mg/kg soil for non Sub1 varieties i.e. Swarna (94.0) & Samba mahsuri (111.33) and for Sub1 varieties i.e. Swarna Sub1 (99.45), Samba mahsuri Sub1 (121.33) & IR64 Sub1 (120.3).

Table 2: Effect of zinc sulphate ongrain number per panicle and panicle weight (g) on Sub1 and non- Sub1 rice varieties exposed to 15 days of complete submergence

Treatment / Varieties	Panicle weight (g)						Grain number per panicle					
	T1		T2		T3		T1		T2		T3	
	A	B	A	B	A	B	A	B	A	B	A	B
V1	14.75	12.79	15.89	14.0	16.09	14.65	90.33	87.67	93.33	89.0	107.33	94.0
V2	16.54	11.66	16.68	11.90	17.82	12.42	104.33	93.90	107.33	96.66	112.33	99.45
V3	14.96	12.39	15.70	12.90	16.30	13.44	125.0	90.67	135.0	97.33	140.0	111.33
V4	15.60	10.77	16.51	11.47	17.37	11.90	129.67	109.67	136.67	109.67	139.0	121.33
V5	14.87	8.63	15.26	9.54	15.23	9.98	132.0	93.33	136.33	110.60	141.0	120.33

Here, A= Controlled condition B= Submerged condition

	Controlled	Submerged	Controlled	Submerged
SEm±	0.267	0.230	4.126	3.278
L.S.D at 5%	0.271	0.665	11.918	9.468

5. Grain yield per plant (g)

The data recorded ongrain yield per plant due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table 3. The maximum grain yield per plant was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (22.75g) & Samba mahsuri (25.84g) and for Sub1 varieties i.e. Swarna Sub1 (24.50g), Samba mahsuri Sub1 (28.84g) & IR64 Sub1 (19.59g) in controlled condition, while in submerged condition, maximum grain yield per plant was recorded at zinc level @ 10.0 mg/kg soil for non Sub1 varieties i.e. Swarna (18.92g) & Samba mahsuri (20.59g) and for Sub1varieties i.e. Swarna Sub1 (17.33g), Samba mahsuri Sub1 (24.09g) & IR64 Sub1 (23.35g).

6. Test weight (g)

The data recorded on test weight due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table 3. The maximum test weight was recorded at zinc level @ 10.0 mg/kg soil for non- Sub1 varieties i.e. Swarna (19.68g) & Samba mahsuri (21.03g) and for Sub1 varieties i.e. Swarna Sub1 (20.98g), Samba mahsuri Sub1 (21.73g) & IR64 Sub1 (20.15g) in controlled condition, while in submerged condition the maximum test weight was recorded at zinc level @ 10.0 mg/kg soil for non- Sub1 varieties i.e. Swarna (19.63g) & Samba mahsuri (19.71g) and for Sub1 varieties i.e. Swarna Sub1 (20.37g), Samba mahsuri Sub1 (19.51g) & IR64 Sub1 (19.11g).

Table 3: Effect of zinc sulphate ongrain yield per plant (g) and test weight (g) on Sub1 and non-Sub1rice varieties exposed to 15 days of complete submergence

Treatments / Varieties	Grain yield per plant (g)						Test weight (g)					
	T1		T2		T3		T1		T2		T3	
	A	B	A	B	A	B	A	B	A	B	A	B
V1	20.83	17.38	21.79	18.39	22.75	18.92	19.75	18.60	19.68	18.94	19.68	19.63
V2	22.92	16.33	23.65	16.55	24.50	17.33	19.85	19.46	20.66	20.16	20.98	20.37
V3	24.85	18.16	25.10	19.08	25.84	20.59	19.39	18.51	20.62	18.80	21.03	19.71
V4	26.79	22.87	28.12	23.30	28.84	24.09	20.56	18.90	21.51	18.95	21.73	19.91
V5	17.93	21.68	18.31	22.70	19.59	23.35	19.53	18.51	19.74	18.82	20.15	19.11

Here, A= Controlled condition B= Submerged condition

	Controlled	Submerged	Controlled	Submerged
SEm±	0.166	0.176	0.195	0.153
L.S.D at 5%	0.481	0.508	0.563	0.444

7. Grain yield per pot (g)

The data recorded ongrain yield per pot due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table 4. The maximumgrain yield per pot was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (39.66g) & Samba mahsuri (32.83g) and for Sub1 varieties i.e. Swarna Sub1 (41.09g), Samba mahsuri Sub1 (32.83g) & IR64 Sub1 (32.03g) in controlled condition, while in submerged condition, maximumgrain yield per pot was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (34.39g) & Samba mahsuri (42.24g) and for Sub1 varieties i.e. Swarna Sub1 (40.27g), Samba mahsuri Sub1 (42.24g) & IR64 Sub1 (38.41g)

Table 4: Effect of zinc sulphate ongrain yield per pot (g) on Sub1and non-Sub1 rice varieties exposed to 15 days of complete submergence

Treatments / Varieties	Grain yield per pot (g)					
	T1		T2		T3	
	A	B	A	B	A	B
V1	35.72	32.95	39.99	33.29	39.66	34.39
V2	38.18	36.84	40.96	38.27	41.09	40.27
V3	30.50	40.93	38.98	42.34	32.83	42.24
V4	39.07	50.62	38.0	42.34	32.83	42.24
V5	28.44	36.19	29.81	37.17	32.03	38.41

Here, A= Controlled condition B= Submerged condition

	Controlled	Submerged
SEm	0.222	0.284
LSD at 5%	0.641	0.821

8. Biological yield (g)

The data recorded on biological yield due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table 5. The maximum biological yield was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (25.34g) & samba mahsuri (26.36g) and for Sub1 varieties i.e. Swarna Sub1 (28.65g), Samba mahsuri Sub1 (26.98g) & IR64 Sub1 (26.19g) in controlled condition, while in submerged condition the maximum biological yield was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (28.38g) & Samba mahsuri (30.41g) and for Sub1 varieties i.e. Swarna Sub1 (33.73g), Samba mahsuri Sub1 (33.32g) & IR64 Sub1 (33.32g).

9. Harvest index (%)

The data recorded on harvest index due to effect of zinc level for rice varieties for controlled and submerged condition have been displayed in table 5. The maximum test weight was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (47.90%) & Samba mahsuri (43.90%) and for Sub1 varieties i.e. Swarna Sub1 (46.67%), Samba mahsuri Sub1 (47.74%) & IR64 Sub1 (45.77%) in controlled condition, while in submerged condition the maximum harvest index was recorded at zinc level @ 10.0 mg/kg soil for non-Sub1 varieties i.e. Swarna (42.25%) & Samba mahsuri (43.93%) and for Sub1 varieties i.e. Swarna Sub1 (48.49%), Samba mahsuri Sub1 (47.0%) & IR64 Sub1 (43.20%).

Table 5: Effect of zinc sulphate on days to biological yield (g) and harvest index (%) on Sub1and non Sub1rice varieties exposed to 15 days of complete submergence

Treatments / Varieties	Biological yield (g)						Harvest Index (%)					
	T1		T2		T3		T1		T2		T3	
	A	B	A	B	A	B	A	B	A	B	A	B
V1	22.99	26.49	22.71	27.27	25.34	28.38	43.60	39.91	45.30	41.65	47.90	42.25
V2	24.41	31.94	27.42	31.57	28.65	33.73	44.98	45.27	45.75	47.60	46.98	48.49
V3	23.25	29.29	24.16	29.85	26.36	30.41	43.89	40.70	44.10	41.47	43.90	43.93
V4	24.08	30.47	25.71	31.07	26.98	33.32	45.74	45.90	47.55	46.68	47.74	47.0
V5	24.19	31.55	25.43	32.64	26.19	33.32	42.56	40.76	43.85	42.03	45.77	43.20

Here, A= Controlled condition B= Submerged condition

	Controlled	Submerged	Controlled	Submerged
SEm±	0.339	0.337	1.180	0.310
L.S.D at 5%	0.981	0.975	3.409	0.897

Discussion

It was observed that the panicle length, ear bearing tiller per pot, panicle weight,grain number per panicle,grain yield per plant, test weight,grain yield per pot, biological yield and harvest index the yield contributing characters significantly influenced by irrespective level of zinc sulphate. Comparison ofgrain yield between the varieties revealed that there was wide variation ingrain yield per plant among the varieties ranging from 17.93g in IR-64 Sub1 to 28.84g in Samba mahsuri Sub1 under controlled condition and 16.33g in Swarna to 24.09g in Samba mahsuri Sub1 under submerged condition. This variation in thegrain yield per plant is a due to the suppression of yield in submerged condition of non Sub1 varieties. Zinc is applied in rice under lowland condition before flooding to prevent zinc deficiency and for increasinggrain yield (Naik and Das 2007)

Conclusions

On the basis of above finding it may be concluded that higher dose of zinc i.e. $ZnSO_4$ @ 10 mg/kg soil could be applied for production of submerged rice varieties. The submerged rice varieties suppress the production of rice in pot condition, but increase in the zinc level has increase the productivity of rice in all varieties. After de-submergence, in standing crop the yield attributes were higher in plant which has higher dose of $ZnSO_4$ (10 mg/kg soil) as well as those containing Sub1gene with them. Preliminary study indicate that escalated nutrient demand from more insensitive and exploitative agriculture, couple with use of higher dose zinc in submerged condition level of $ZnSO_4$ (10mg/kg soil) was found superior with varieties of rice.

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