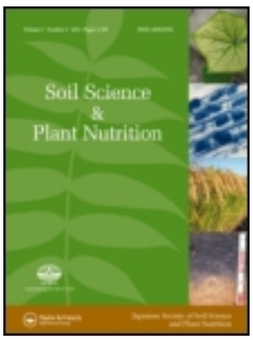

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EFFECT OF STANDING WATER LEVEL ON LODGING BEHAVIOUR OF RICE PLANTS (*ORIZA SATIVA L.* - VAR. T_3)

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Throughout India and particularly in the higher rainfall areas of the west, lodging is the greatest cause of loss to cereal growers. It is true, of course, that breeders have been striving to produce varieties with shorter and stronger straw and have achieved notable success. But concurrently, rates of nitrogen applications have been increased.

SEN (1937)(1) reported that submergence of land was favourable for tiller production during the 1st, 2nd and third weeks after transplanting in the field. KRANTZ and CHANDLER (1951)(2) after an extensive study reported that lodging behaviour in cereals is closely related to soil fertility. KATO and YASUDA (1925)(3) showed that there is positive correlation between lodging and depth of irrigated water.

Method

This experiment was carried out during the years 1964 and 1965 in the Kharif season (June to October) at the Research farm of the College of Agriculture, Banaras Hindu University, India. T_8 a medium maturing variety was selected for the present investigation. Five treatments were made in the following manner:-

Treatment No.	Treatment	Symbol
1.	Standing water level 0″ (Control)	L_0
2.	Standing water level 1″	L_1
3.	Standing water level 2″	L_2
4.	Standing water level 3″	L_3
5.	Standing water level 4″	L_4

Simple randomised Block design was adopted. Healthy and stout seedlings from three weeks old nursery were procured for planting operation. The transplanting was done on 31st July, 1964. Seedlings were planted at a distance of 9″ row to row and 6″ plant to plant. Three seedlings were planted at one place. To study the association between some of the attributes, and also to note the effect of unit change in one variable on another, correlation trends of the following variables were recorded:-

(1) Breaking strength vs. dry matter
(2) Length of internode vs. Breaking strength
(3) Diameter of internode vs. Breaking strength.

Experimental Findings

The relative influences of different standing water levels on lodging behaviour of paddy have been investigated. Data on number of

Table 1. Effect of different water levels on number, diameter and length of 4th internodes.

Treatments	No. of Internodes	Diameter of Internodes	Length of internodes in cm
L_0	4.480	1.869	20.167
L_1	4.671	2.221	20.657
L_2	4.560	2.623	21.801
L_3	4.789	2.330	20.993
L_4	5.300	2.456	20.440
C. D. at 5% level	0.44938	0.6528	4.224

Table 2. Effect of different water levels on number of grains per earhead.

Treatments	Replication			Total	Mean
	R_1	R_2	R_3		
L_0	42.50	54.83	54.00	151.33	50.443
L_1	50.30	75.75	55.63	181.68	60.560
L_2	89.50	86.40	89.50	265.40	88.466
L_3	79.20	75.50	67.64	222.34	74.115
L_4	84.00	76.15	65.65	224.80	74.933
Total	344.50	368.63	332.42	1045.55	

C. D. at 5% level = 47.616

Table 3. Effect of different water levels on fresh weight of upper parts of the rice plant in gms.

Treatments	Replication			Total	Mean
	R_1	R_2	R_3		
L_0	78.0	128.0	34.0	240.0	80.0
L_1	72.0	120.0	106.0	298.0	99.3
L_2	136.0	104.0	93.4	333.4	111.1
L_3	138.0	111.0	146.0	395.0	131.8
L_4	155.0	195.0	199.0	549.0	183.0
Total	579.0	658.0	478.4	578.4	

C.D. at 5% level = 61.82

Table 4. Effect of different water levels on dry matter per unit length of the basal part, weight of 1000 grains and breaking strength of the 4th internodes of the rice plants.

Treatments	Mean dry wt. in gms	Weight of 1000 grains in gms	Breaking strength in gms
L_0	4.250	21.016	303.9
L_1	2.849	21.823	311.0
L_2	4.248	23.686	317.6
L_3	4.133	23.493	298.4
L_4	3.991	26.493	296.0
C.D. at 5% level	2.15	8.02	

Table 5. Effect of different water levels on nitrogen content of stem (leaf sheath and culm) of the rice plants at several stages of growth.

Treatments	Age in days		
	19	38	57
L_0	1.200	1.640	1.380
L_1	1.180	1.640	1.390
L_2	1.200	1.663	1.392
L_3	1.240	1.690	1.410
L_4	1.260	1.694	1.421

internodes, diameter of fourth internode, number of grains per earhead, wt. of 1,000 grains, breaking strength of straw, fresh wt. of upper parts, dry wt. of lower 10 cm basal part and chemical composition of the rice plants have been collected.

(1) *Effect of different water levels on number, diameter and length of internodes.*

Measurements on the length, number and diameter of internodes were carried out 94 days after transplanting. The average values have been presented in Table 1.

The above table clearly indicates that L_4 and L_3 enhanced the number of internodes over L_2, L_1 and L_0. Regarding the influence of different water levels on diameter and length of 4th internode, it was noted that L_2 and L_4 showed dominant influence over L_3, L_1 and L_0.

(2) *Effect of different water levels on number of grains per earhead.*

Statistical analysis of table 2 revealed the significant influences of levels of water on the number of grain per earhead. A critical examination of table 2 indicated that L_2 treatment had maximum number of grains per earhead followed by L_4, L_3, L_1 and L_0 respectively.

Table 6. Effect of different water levels on nitrogen content of leaf of the rice plants at several stages of growth.

Treatments	Age in days		
	19	38	57
L_0	2.400	2.261	2.600
L_1	2.402	2.290	2.609
L_2	2.410	2.295	2.710
L_3	2.420	2.400	3.000
L_4	2.607	2.500	3.100

Table 7. Effect of different water levels on nitrogen content of root of the rice plants at several stages of growth.

Treatments	Age in days		
	19	38	57
L_0	0.490	0.600	0.800
L_1	0.573	0.690	0.879
L_2	0.600	0.730	0.927
L_3	0.700	0.800	0.890
L_4	0.732	0.839	0.862

(3) *Effect of different water levels on fresh weight of upper parts of the rice plants.*

Table 3 showed that treatment L_4 was superior to the others, although statistically there was not a highly significant result.

(4) *Effect of different water levels on dry matter per unit length of the basal part, wt. of 1,000 grains and breaking strength of fourth internodes of the rice plants.*

The data on the dry matter of 10 cm of basal part of culm have been presented in table 4 and it is evident from the table that L_0 produces the highest dry weight followed by L_2 treatment. Weight of 1,000 grains was higher in L_4 treated plants than in other treatments. Further examination of table 4 revealed that in general the breaking strength increases up to L_2 water treatment. After that a sudden fall in breaking strength occurs at L_3 and L_4. So the maximum increase in breaking strength was recorded under L_2 treatment. The lowest efficiency of L_4 was also clearly manifested. The treatments L_0, L_2 and L_1 did not exhibit significant differences in breaking strength.

Table 8. Effect of different water levels on phosphorus content of stem (culm + leaf sheath) of the rice plants at several stages of growth.

Treatments	Age in days		
	19	38	57
L_0	0.478	0.281	0.725
L_1	0.479	0.288	0.729
L_2	0.490	0.291	0.801
L_3	0.484	0.289	0.789
L_4	0.482	0.287	0.773

(5) Effect of different water levels on chemical composition of the rice plant.

Determination of nitrogen, phosphorus and potash was made in stem (culm + leaf sheath) and percentage of nitrogen in leaf and root. Tables 5, 6 and 7 present the value of nitrogen determination of stem, leaves and roots respectively, while Tables 8 and 9 present the values for phosphorus and potash content of stem respectively.

As is evident from table 5, the various treatments show only slight differences at any stage of growth. There were no marked differences between the treatments.

The same condition occurs with the nitrogen content of leaves, but from the critical examination of table 6, it is clear that there is marked difference between L_0 and L_4 at all the stages of growth. The table indicates that L_4, L_3, L_2, L_1 and L_0 gave performance in that order.

As regards the nitrogen content of roots there was great difference between the treatments. Treatments L_4 and L_3 showed dominant effect in increasing nitrogen percentage of the root but this increase was only up to 38 days. After 57 days L_2 showed effect in increasing nitrogen content of root. It is clear from table 7 that comparative nitrogen content of L_3 and L_4 treated plants decreased in the third stage.

As is evident from table 8, there is very slight difference in P content of stem in all the three stages of life cycle upto 57 days of transplanting. Treatment L_2 gave the highest value of all the treatments.

No well marked differences due to treatments could be registered in relation to K content of stem at any stage. L_2 showed better performance at all the stages. Table 9 clearly shows the trend of relationship between treatments and K content of paddy stem.

Table 9. Effect of different water levels on potash content of stem (culm + leaf sheath) of the rice plants at several stages of growth.

Treatments	Age in days		
	19	38	57
L_0	1.340	1.641	1.930
L_1	1.343	1.657	1.941
L_2	1.381	1.680	1.990
L_3	1.372	1.680	1.972
L_4	1.370	1.659	1.530

(6) Correlation study

The degree of association between dry matter accumulation versus breaking strength, length of internode versus breaking strength and diameter of stem versus breaking strength were also studied and the relevant co-efficients of correlation were computed which are given below:-

(i) Correlation co-efficient (r) = 0.017
(ii) Correlation co-efficient (r) = 0.590
(iii) Correlation co-efficient (r) = 0.090

From the above values it is evident that a highly significant positive correlation exists between the above variables.

Discussion

It has been proved in numerous experiments that certain plant characteristics such as length of internodes, dry matter per unit length, diameter of internodes, fresh weight of upper parts, breaking strength of straw and others determine to a great extent the tendency of a plant to lodge. Data on these characters as influenced by varying water levels were presented in the preceding pages. It is the intention here to analyse and discuss how far these characters correlated with the standing ability of a plant and also how far these could be used as an index for determining the tendency of a plant to lodge.

In the present investigation an increase in the water levels consistently increases the number of internodes, because the length of stem increases due to high water levels.

With increased water levels there is an increase in the diameter of internodes upto 2"

water levels. After that there is a slight reduction in diameter of fourth internodes. The reduction is due to elimination (KRAUS, 1908) (4) (WELTON, 1928) (5) (WELTON and 1931) (6) and lack of lignification in the fourth internode.

Number of grains increased with increase in water levels upto 2". After that it decreases; when plants lodge their grain number is reduced (ENGOVOV, 1938) (7).

The increase in fresh weight of upper parts is due to uptake of more nitrogen and other nutrients in water lodged plants (OKADA, 1932) (8). That is why plants lodged in the case of 3" and 4" water levels.

In this experiment, there was reduction in dry weight of 10 cm basal part in 4" and 1" water levels treated plants and maximum dry weight was observed in 2" and 0" water levels treated plants. It is very interesting that dry matter of stem is closely correlated to breaking strength.

Breaking strength of straw has been recognized as a good measure of tendency to lodge (SALMON, 1931) (9), (DAVID and STANTON, 1932) (10). Here in this investigation — breaking strength of straw increases up to 2" water level and decreases after that. The reason for decreased breaking strength is due to low dry matter of 10 cm basal parts and less diameter of fourth internodes (SINGH and TAKAHASHI, 1962) (11).

It is a well known fact that weakness of straw has been attributed to the low amount of silica, potassium, lignin, cellulose and polysaccharides and to the excess of nitrogen. It has been found that with increase in water levels consistent increase in nitrogen content takes place, due to more uptake of nitrogen.

Phosphorus and potassium content of stem is lower in untreated plants than in treated plants at all the stages of growth. It is interesting to note that at later stages phosphorus and potash content of stem was lower at 4" and 3" water levels than at 2" water level, but it was still higher than at 0" water level. The reasons are:-

(i) At later stages, phosphorus and potash get distributed in a larger plant body as there was increased growth under these treatments.

(ii) The second reason is that at later stages there was lodging in 4" and 3" water level treated plants, and because of hampered uptake and translocation in lodged plants, phosphorus and potash contents were slightly reduced.

Summary

Results of this investigation indicated the most profound influences of standing water levels on practically all the characters related to lodging. Statistically significant differences were recorded in number, diameter and length of internodes. In general 4" treated plants in case of number of internodes, and 2" water level in case of diameter and length of internodes proved to be best as compared to others. It was concluded that 4" water level produces maximum fresh weight in upper parts and also higher weight of 1000 grains. Breaking strength and dry matter accumulation in 10 cm basal part were maximum at 2" water level. Nitrogen content increases with each increase in water level in all plant parts, but phosphorus and potash content did not exhibit significant differences.

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