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Effect of Soil Moisture Regimes on Germination, Root Growth and Establishment of Wheat (*Triticum aestivum*) Varieties

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Abstract

Pot experiment was conducted to examine the effect of saturated soil moisture on germination, root growth and establishment of wheat in comparison with normal condition. Four wheat varieties viz., HD 2643, HD 2285, HUW 234 and Kundan were considered for the study. Reduction in germination (37%), plant height (9%), leaf area (11%) and dry matter (25%) was recorded in saturated condition over normal condition. High root growth was recorded under saturated soil moisture condition, which was 31% more over normal condition. Among four varieties, the highest root growth and lowest reduction in other growth parameters were found in HD 2285. The varieties HUW 234 and Kundan were performed alike next to HD 2285. HD 2643 showed poor response which was more susceptible to saturated soil moisture condition. Varieties, water regimes and its interactions were found significant.

Introduction

Productivity of agriculture in eastern India especially Bihar, is very low due to many production constraints. Excess soil water and water scarcity are causing yield losses in many crops. Monsoon strikes during second week of June in Bihar. Normal rainfall of Bihar is about 1200 mm, 80% of which is received in 4 months from June to September. There is a short spell of rain generally during first fortnight of October. In lowland rice, water stagnation remains till November followed by excess soil moisture till December. Rice harvest has to be done when the soil is highly saturated and in some occasion on standing water. Due to this excess quantity of residual soil mositure, it takes more than one month to prepare land for subsequent wheat crop which leads to delay of sowing. Timely sowing of any crop is a precursor to get better yield. There are number of wheat varieties popular in this region under normal cultivation conditions. Performance of these wheat varieties under adverse soil moisture condition is not standardized. Any variety, which establishes well under this condition, will eliminate delayed sowing. An experiment was planned to study the effect of saturated soil moisture condition on germination, root growth and establishment of wheat varieties in comparison with normal cultivation.

Materials and Methods

Soil was very deep, poorly drained with clayey surface texture. Texture was silty clay with sand, silt and clay content being 17, 42 and 41%, respectively. Bulk density was 1.45 g/cc and porosity was 44.3%. Maximum water holding capacity and saturated hydraulic conductivity were 49.1% and 0.3 cm/hr respectively.

Experiment was conducted in pots during 1999-2001 at ICAR Research Complex for Eastern Region with four wheat varieties namely HD 2643, HD 2285, HUW 234 and Kundan. Two water regimes were considered viz., 5 cm irrigation was give when the soil moisture reached 25% and saturated. Water applied frequently to maintain saturation point (48-49%). Seeds were sown at 1 to 2 mm depth. Treatments were replicated four times and arranged in completely randomized design. Soil moisture content was monitored constantly with the help of Time Domain Reflectometry (Trase System). Germination was counted from 5th day onwards. Growth parameters were measured at tillering stage of crop. Leaf area was measured with automatic leaf area meter (Licor Model-LI-3050A).

Seedlings were removed along with soil with the help of hand hoe. They were kept in water for few hours and the soil particles were removed by running water with gentle force. All the roots were removed from the plant and the moisture content was removed with tissue paper and weighed. Root parameters were measured with root length measuring system (Newman, 1966).

Result and Discussion

Seeds under saturated condition sprouted 2 days earlier than normal irrigation condition. But the germination was poor when the time advanced and at the time of final count. The average germination percentage was 92 and 58 per centages under field and saturated condition, respectively (Table1). The reduction in germination under saturated condition was 59% over field condition. Higher bulk density and very low hydraulic conductivity of the soil hamper the drainage. It leads to soil saturation for long period and reduce the oxygen availability for respiration of seeds. Each variety also showed variable reduction in germination under saturated soil moisture condition to the tune of 60, 20, 35 and 35 per cent of HD 2643, HD 2285, HUW 234 and Kundan varieties, respectively. It may be due to shortage of oxygen which resulted in poor germination (Heydecker and Orphanor, 1968). The highest percentage of germination was obtained in HD 2285, which was significantly differing from other varieties. Varieties like HUW 234 and Kundan were found on par. Genotypic variation in tolerance to waterlogging exists in wheat (Davies and Hillman, 1988). Variety HD 2643 was found highly susceptible to saturated condition. Soil moisture regimes, varieties and interaction of both were found significant.

Leaf area of wheat varieties measured under saturated condition was found reduced (13 %) as compared to normal condition. Leaf area of HD 2285 was 36.53 cm^2/plant, which was highest among all varieties followed by HUW 234 and Kundan. Wheat variety, HD 2643, was the least in leaf area measured among four varieties. The reduction of leaf area was 41 % in HD 2643 compared to HD 2285. Gardner and Flood (1993) found that water logging reduced leaf elongation, kernel number and final yield in cereals.

Mean plant height of the wheat varieties grown under saturated condition was reduced which was 11 per cent lesser than normal condition. The difference in plant height amongst different varieties was pronounced more under saturated soil condition which were 24, 1,17,4 per cent in HD 2643, HD 2285, HUW 234 and Kundan, respectively over normal condition. Hence the reduction in height was less in HD 2285 and high in HD 2643.Treatments and interaction were found significant.

Adventitious roots were found developed in all the wheat varieties, which were grown under saturated conditions as observed by Cannel 1979. (Table 2). The mean increase in root weight in saturated soil moisture was 24 per cent more over normal condition. Highest difference in root weight between normal and saturated condition was observed with HD 2285(41%) followed by Kundan(10%), HUW 234(9%) and the lowest difference was observed with HD 2643(4%). The variety HD 2285 recorded the highest root weight (195%) in saturated condition compared to the susceptible variety HD 2643 which recorded the lowest root weight. Root length was 76 per cent higher in saturated condition over normal condition. Among varieties, HD 2285 recorded 280 per cent root growth under saturated condition compared to HD 2643. Average surface area of all the varieties was 37 per cent higher under saturated condition compared to normal condition. In saturated condition, HD 2285 recorded 327 per cent higher surface area compared to HD 2643 followed by Kundan(150%) and HUW 234(75%). Root diameter was found reduced under saturated condition. The reduction was 38 per cent over normal condition. Though the root length and surface area were found lower in HD 2643 it has recorded highest root diameter which may be due to crop stress under excess soil moisture. All the varieties grown under saturated soil moisture were recorded higher root volume density over normal condition and it was highest in HD 2285.

Difference was observed in total dry matter (TDM) production among wheat varieties grown under saturated condition with normal condition. The TDM was reduced under saturated moisture condition, which was 17 per cent less over normal condition, and the interaction between varieties and soil moisture content was significant and indicated that the wheat varieties responded negatively to soil saturation. The highest dry matter production was observed in wheat variety HD 2285 and lowest in HD 2643. Oxygen deficiency caused by waterlogging reduces shoot and root growth (Trought and Drew, 1980, Sayad, 1998, Collaku and

TABLE 1. Basic characteristics of soil.

Soil parameters	Values
Taxonomic class	Vertic Ustochrept
Sand (%)	35
Silt (%)	28
Clay (%)	37
Textural class	Clay loam
Bulk density (kg m^{-3})	1.47
Saturated hydraulic conductivity (cm hr^{-1})	0.31
pH	7.4
EC (dSm^{-1})	0.26
Organic carbon (g kg^{-1})	6.5
Available N (kg ha^{-1})	290
Available P (kg ha^{-1} as P_2O_5)	32
Available K (kg ha^{-1} as K_2O)	398

Harrison, 2002). The reduction of TDM in HD 2285 was very less (7%) under saturated soil moisture condition and it was highest in Kundan (37%) followed by HD 2643(22%) and HUW 234(18%).

Number of tillers and number of leaves per plant were found higher under saturated soil moisture condition. Though the growth recorded numerically higher values, but statistically it was non-significant.

The germination of wheat was adversely affected by saturated soil moisture condition. The varietal differences observed in the study indicate that timely wheat sowing can be done even when the soil moisture content is close to saturation level by adoption of wheat varieties like HD 2285 which is resistant to saturated moisture condition. A good amount of residual soil moisture can be utilized effectively in low lands of river basins in Eastern India. Optimum fertilizer dose has to be identified for obtaining the higher yield under saturated soil moisture condition.

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Table 2. Effect of soil water regimes on germination and plant growth parameters of wheat varieties

Sl. No	Varieties	Germination (%)		Plant height (cm)		Leaf area (cm2/plant)		Total dry matter (g/plant)	
		Normal condition	Saturated condition	Normal condition	Saturated condition	Normal condition	Saturated condition	Normal Condition	Saturated condition
1	HD2643	89	36	17.77	14.32	23.31	15.16	0.268	0.219
2	HUW 234	92	60	20.58	20.35	32.17	29.63	0.349	0.295
3	Kundan	94	61	18.70	17.98	34.56	29.00	0.339	0.279
4	HD2285	93	75	21.02	18.02	34.44	36.53	0.361	0.337
	Mean	92	58	19.52	17.67	31.12	27.58	0.379	0.283
	CD(0.05)	15.89		3.09		6.76		0.172	

Table 3. Root Parameters of wheat varieties under two water regimes

Sl. No	Varieties	Weight (gm/plant)		Surface area (cm^2)		Diameter (cm)		Length (cm)	
		Normal condition	Saturated condition	Normal condition	Saturated condition	Normal condition	Saturated condition	Normal Condition	Saturated condition
1	HD2643	0.87	0.91	167.8	192.3	0.063	0.049	424	625
2	HUW 234	1.16	1.27	289.9	337.0	0.071	0.049	650	1095
3	Kundan	0.97	1.07	235.0	291.3	0.066	0.047	567	987
4	HD2285	1.04	1.77	367.0	627.8	0.065	0.047	899	1756
	Mean	1.01	1.26	264.93	362.10	0.066	0.048	635.00	1115.75
	CD(0.05)	0.15		15.60		NS		52.75	

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