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Rainfall Intensity as Affected by Water Pressure and Height of Rainfall Simulator

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Abstract

Rainfall characteristics such as rainfall intensity, raindrop size and uniformity need to be determined as these are the deviasting parameters in soil erosion. In pressurized irrigation, water is applied, through the network of pipes, to the crop at required depth with the desired pressure. There exists unique relationship (Q = KHx) between pressure and discharge. However, the intensity of rainfall, if simulated, at various pressure, the relationship between pressure and rainfall intensity should be known. The PE of raindrop varies with height of rainfall. The impact of rainfall, in detachment of soil particles, also varies with raindrop size.

As such, to know the effect of rainfall height on uniformity, rainfall intensity, raindrop size & wetted diameter at different water pressure, the experiment was carried out on Instructional Farm of Dr. Annasaheb Shinde College of Agricultural Engineering, MPKV, Rahuri by using rainfall simulator. The rainfall was simulated with the help of turbo nozzle. The height of simulator were maintained at the interval of 0.5 m as 4.2, 3.7, 3.2 and 2.7m. The effect of water pressures of 0.5, 1.0, 1.5, 2.0 kg/cm^2, at these heights, were studied on rainfall intensity, raindrop size and wetted diameter.

The water pressure and rainfall intensity were observed inversely proportional to each other. For simulated rainfall, the raindrop size were found increased with increase in rainfall intensity. Rainfall intensity was found directly proportional to height of rainfall.

Keywords: Rainfall intensity; Rainfall simulator; Water pressure.

INTRODUCTION

To meet the food requirement of the increasing population of India, the production per unit of land need to be raised with protecting the ecology. The fertile soil is lost because of single runoff event leading into the land degradation and reduced crop protection. The impact of rainfall, causing runoff and soil erosion, depends on the parameters like rainfall intensity, raindrop size, potential energy, kinetic energy, etc. If rainfall and runoff are properly managed with effective soil and water conservation techniques, then, the loss of water and soil can be controlled significantly. Otherwise, may cause loss of water and soil to the significant extent.

Simulated rainfall has numerous advantages over the natural rainfall for many erosion studies. For many years, rainfall simulators have been used to accelerate research in soil and runoff from agricultural land. In addition to greater control for field studies, simulated rainfall is readily adoptable to highly controlled laboratory. Such studies present the possibilities for major advances in understanding of basic erosion process. Some

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scientists have worked on rainfall simulator such as **Tandale (2007)** investigated the relationship between rainfall intensity, raindrop size, runoff, and soil loss and infiltration rates. **Shrivastava and Das (2000)** kept the simulation height of rainfall simulator as 4m and size of soil plot was 4x1m^2. To obtain different rainfall intensities and raindrop sizes from rainfall simulator, different types of emitter's viz. micro sprinkler, micro tubes and distribution connectors were used. Raindrop size obtained was less than or equal to 4mm. **Foltz, B. and Charles, L. 1995**. The kinetic energy field under a rainfall simulator. Arid land Research center, Tottori University, Tottori. RS experiments have the ability to generate rainfall events with similar characteristics as natural rain **(Norazlina Bateni, *et al*. 2018)**. **Daniel Carvalvo *et al.* 2023** studied soil and water losses with simulated rainfall considering experimental plots and rainfall patterns

There is considerable evidence of a close association between soil erosion and rainfall intensity. Rainfall intensity is particularly important as a potential parameter of erosive because it is the only feature of rainfall which, in addition to amount, is frequently recorded at conventional meteorological stations. The intensity is computed from rate of change in the quality of rainfall recorded. In view of investigation the relationship between the rainfall intensity, rainfall height, raindrop size and uniform coefficient with simulated rainfall, the experiment was conducted with the objectives 1. To study the effect of water pressure on rainfall intensity and 2. To study the effect of height of rainfall simulator on rainfall intensity.

MATERIALS AND METHODS

A field experiment was conducted with rainfall simulation system installed in the Instructional Farm of Dr. Annasaheb Shinde College of Agricultural Engineering Mahatma Phule Krishi Vidyapeeth, Rahuri.

Rainfall simulation system

Rainfall simulation system (Fig. 1) was erected in the and used for present study. The various components of rainfall simulator are elaborated in the following sections:

Rainfall generation and control unit

This was the main unit of rainfall simulation system, used for the generation and control of simulated rainfall. The unit was made of PVC pipes, a lance made up of brass material and turbo nozzle. A nozzle was mounted on a lance, which received the water from the water source through centrifugal pump at different pressures. The heights of nozzle was kept as 4.2m, 3.7 m, 3.2 m and 2.7 m from the ground surface to Lance was connected to the PVC pipes. At the junction of lance and PVC pipe pressure gauge was fixed to monitor the water pressure. The main components were turbo nozzle, flow regulating valve, pressure gauge, centrifugal pump and water source, etc.

Turbo nozzle

A Turbo nozzle was used for simulation of rainfall. The nozzle used was of.

Version standard: M 61. 610. 20 with AMT $_{\varphi}$ 15 mm, spray tip hole $_{\varphi}$ 1.2 mm with ¼" BSPM. Ball joint, maximum operating pressure-50 bar, weight-250g, materials-brass and aluminum.

Flow regulating valve

In order to supply water to the simulation unit from the water source at different operating pressure, a brass made 15 mm diameter flow regulating valve was fitted, on the bypass line. By regulating this valve the water inflow rate to the simulation unit is controlled to obtain the desired intensity of generated rainfall.

Pressure gauge

A pressure gauge having a dial diameter of 6 cm was mounted on main supply line on a lance just near the nozzle to monitor the water pressure. In the present study, the pressure was varied from 0.5 to 2 kg/cm^2 at an equal increment of 0.5 kg/cm^2.

Centrifugal pump

A single phase 0.5 hp centrifugal pump was used to as water at various pressures to the simulation unit. The pump was operated through a three phase electric supply line. A PVC pipe of 19 mm (3/4 inch) diameter was used to supply water to simulation unit.

Water source

A PVC water storage tank of capacity 500 lit. Was used as a water source. It receives water from a regulator water supply through a PVC pipe.

Soil plot

The simulated rain was received over properly oriented leveled soil plot below the sprinkling system. The condition of the soil plot was maintained as natural as possible during the experiment.

Rainfall intensity

Calculation for rainfall intensity was based on amount of water collected during each time interval. Rainfall intensity was calculated for water pressure range from 0.5 to 2.0 kg/cm^2 at an increment of 0.5 kg/cm^2.

The required water pressure at increment of 0.5 kg/cm^{2}was adjusted using flow regulating valve. The total quantity of water received through the nozzle at desired water pressure was collected in plastic bucket for 1 minute duration. The collected volume was measuring cylinder. The amount of water discharge through nozzle was measured and the wetted

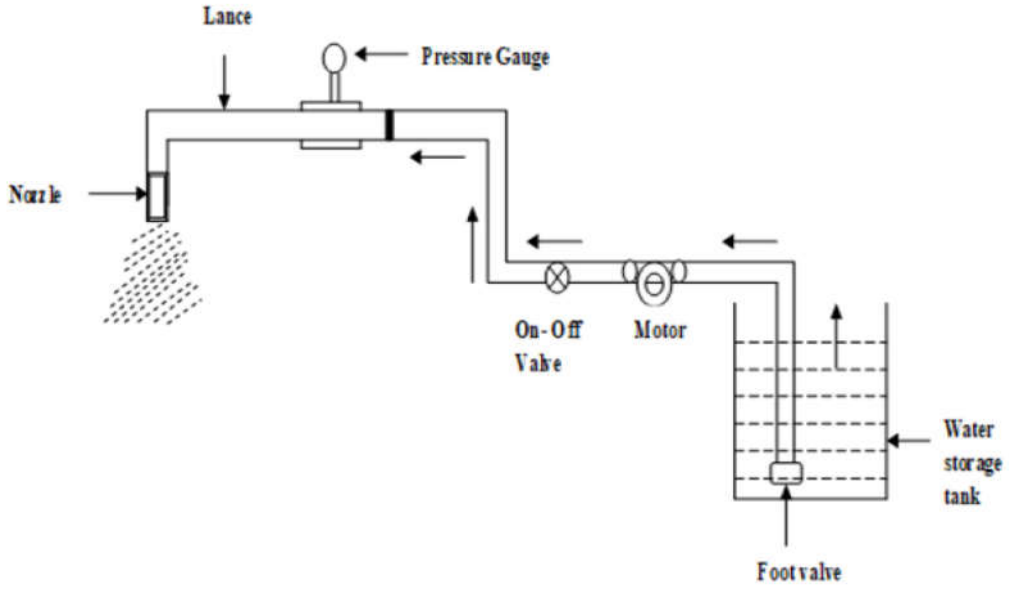

Fig. 1: Rainfall simulator

diameter was measured to compute the area of circle formed due to simulated rainfall. The depth of rainfall received during the five minutes was computed by dividing the volume of water discharged through nozzle by wetted area. This was then converted in rainfall intensity in cm/h. The rainfall intensities for different pressure were computed.

Height of Rainfall Simulator (single nozzle)

The different nozzle heights of rainfall simulator were adjusted at 4.2, 3.7, 3.2 and 2.7 m from the ground surface. In view of studying their effect on the rainfall intensity and raindrop size at different water pressures.

Effect of water pressure on rainfall intensity at different height of rainfall simulator

The rainfall intensity for simulated rainfall was observed 3.96 to 1.75 cm/h for water pressure of 0.5 to 2 kg/cm^2, the water pressure was measured near the nozzle. The observation are given in table 1.

RESULTS AND DISCUSSION

Table 1: Relationship between water pressure and rainfall intensity

Heights (m)	Water pressure (kg/cm^2)	Simulated discharge (ml)	Wetted diameter (m)	Wetted area (m^2)	Rainfall intensity (cm/h)
4.2	0.5	5040	1.8	2.545	3.96
	1.0	6842	2.7	5.726	2.39
	1.5	8410	3.0	7.068	2.37
	2.0	11802	3.6	10.178	2.32
3.7	0.5	1400	1.8	2.54	3.30
	1.0	2000	2.3	4.15	2.88
	1.5	2204	2.7	5.72	2.35
	2.0	2680	3.0	7.06	2.30

Table Cont...

3.2	0.5	1780	2.1	3.46	3.06
	1.0	2560	2.8	6.15	2.49
	1.5	3330	3.3	7.06	2.33
	2.0	3900	3.6	9.08	2.30
2.7	0.5	1920	2.5	4.90	2.35
	1.0	2320	2.8	6.15	2.26
	1.5	2840	3.2	8.04	2.12
	2.0	3300	3.8	11.33	1.75

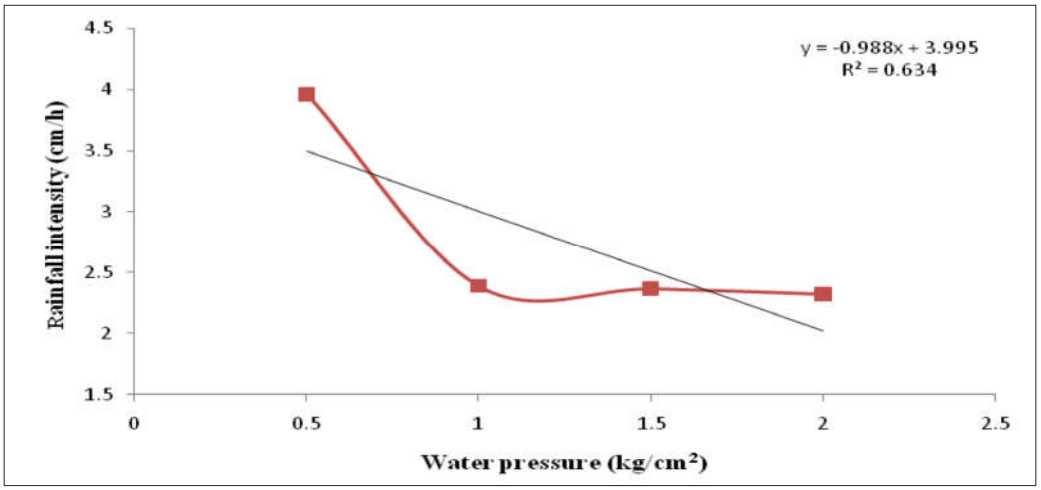

Fig. 2: Relationship between rainfall intensity and water pressure at height 4.2 m of rainfall simulator

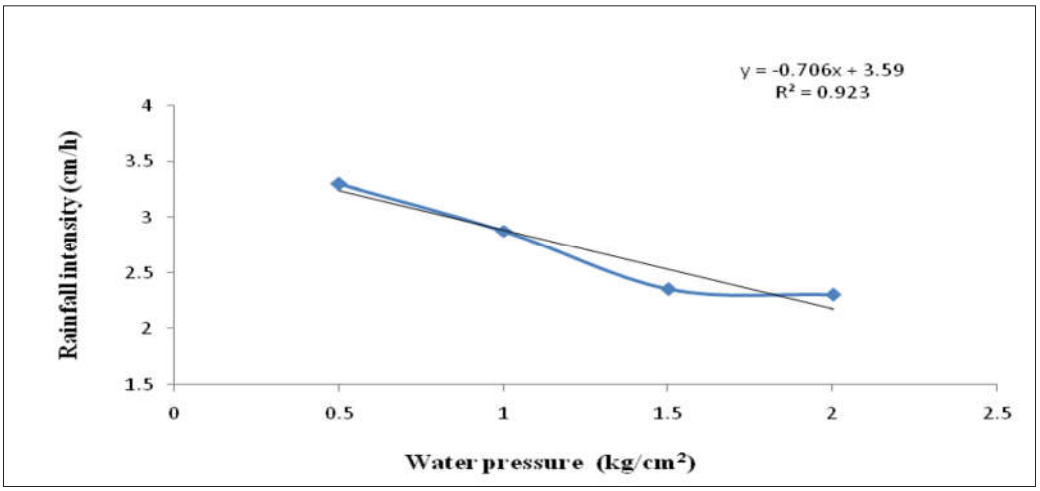

Fig. 3: Relationship between rainfall intensity and water pressure at height 3.7 m of rainfall simulator

As the wetted area increases with increase in water pressure the intensity of simulated rainfall decreases. This relationship is depicted in Fig. 2 and Fig. 3 for height of rainfall 4.2 and 3.7 m respectively. The similar trend was also observed for 3.2 and 2.7 m heights of rainfall simulator. It is revealed from table 1 and Fig. 2 and Fig. 3 that with increase in water pressure, the rainfall intensity decreases.

Effect of height of rainfall on rainfall intensity at different water pressure

With constant water pressure, relationship between height of rainfall and rainfall intensity as depicted in above figures and table it is revealed that the rainfall intensity increases with height of rainfall simulator.

CONCLUSIONS

On the basis of results obtained following conclusions are drawn:

1. The water pressure and rainfall intensity are inversely propositional for the spray obtained from M-61.610.110 Turbo nozzle of rainfall simulator.
2. The rainfall intensities is directly proportional to height of rainfall simulator.

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