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Studies on effect of pressure on the radius of throw and discharge of 16mm nozzle raingun and evaluation

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Abstract
The relationships *viz*., pressure v/s radius of throw, pressure v/s discharge and were developed for standalone rain gun at different riser heights. The linear, logarithmic, power and exponential compound, inverse, growth and logistic types of equations were fitted for these relationships. The best relationships were selected based on the value of regression coefficient. The discharge of raingun increases with operating pressure. This fact indicates the scope for deciding the operating pressure to obtain the desired precipitation rate according to the soil type. However the nature of variation of discharge and radius of throw with operating pressure were different for different makes of raingun. Similarly the radius of throw of raingun was found to be increased with operating pressure.

Keywords: Raingun, pressure, discharge, radius of throw

Introduction
Amongst sprinkler irrigation systems, rain gun can be used most effectively for irrigating larger fields in short period and with minimum labour requirement. This system consists of a saint sprinkler (powerful mega sprinkler) that throws a large amount of water (up to 500 litre/min.) to a distance up to radius of 90 feet and even more, like artificial rain. Basically, two types of rain guns are available in the market (1) gear driven type and (2) hammer action type. The rain gun sprinkler system may be portable or fixed type. Giant sprinklers usually have one large nozzle with smaller supplemental nozzles for pattern gaps filling, this system is not utilized for the soil whose infiltration rate is lower than 4 mm/hr and also not suitable for the regions of appreciable wind and delicate crops.

Nowadays number of companies are manufacturing and promoting rainguns. Operating pressure of rain gun varies from 2 to 5 kg/cm^2. 3 to 10 HP high head and low to medium discharge type pumps are required for the operation of rain-gun, Depending on a model, at a time, a rain gun can irrigate 0.5 to 1 ha area of land within 2 to 3 hrs. As stated earlier, this system can save considerable labour, time and electricity besides irrigation water. However, giant sprinklers usually have low water distribution efficiency, if the system is not designed properly.

However adequate information is not available on hydraulic characteristics of raingun irrigation system. Therefore, present investigation was undertaken to study pressure v/s discharge and pressure v/s radius of throw relationships of different makes of rainguns with different riser heights.

Material and Methods
The experiment was conducted at the Agricultural Research Station, Acharya N G Ranga Agricultural University, Perumallapalli (Andhra Pradesh), India situated between 13.5° N latitude and 79.5° E longitudes. The altitude of the place is 182.9 meters above mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh.

The experimental setup consisted water source, pump, field and raingun irrigation system. The two submersible pumps of 7.5HP was installed on the bore well to lift and supply water to raingun irrigation system through mains and sub. Mains of pvc pipe. The rpm of pump was 1440 and operated on 331/420V.Additionally to create more booster is fixed at the corner of the field. The diameter of the suction pipe was 6.35 (2.5”) whereas of delivery pipe was 6.35 (2.5”). The experiment field was properly levelled to the zero slope and the vegetations in the field and around the field were removed so to maintain the same conditions throughout the period of experimentation.

Raingun irrigation system

The system consisted of the components such as mainline, rainguns, riser and miscellaneous pressure gauge, pitot tube etc. The mainline used for the experiment was of 6.35 cm (2.5") diameter and the length was 35 m. The five different rainguns having different nozzle size were used. The specification and other details are presented in Table 1.

Table 1: The detail specification of the raingun

S. No	Specification	Make-A
1	Manufacturing company	Jain Irrigation Pvt. ltd., Jalgaon
2	Brand name	Komet
3	Nozzle size	16 mm
4	Drive mechanism	Hammer action

The riser of galvanized pipe of 3.81 cm (1.5") diameter was used for Komet Raingun, pelican and Penguin rainguns is shown in figure 3.8. The risers of three different heights *viz.* 1.5, 2.0 and 2.5 so were used for developing the relationships and estimating the performance parameters. The riser pipes were threaded externally at both the ends and were provided with the nipple of 1.5 cm diameter (internally threaded) for connecting the pressure gauge. The pressure gauge connected to the riser and the regulating valve connected to mainline were used to monitor the desired pressure.

Observations

The observations were recorded to develop pressure v/s discharge and pressure v/s radius of throw of 16 mm nozzle raingun for all the combinations of nozzle size, pressure and riser height. Three different riser heights 1.5, 2.0 and 2.5 m were used. The pressures at the riser or near the inlet of the nozzle were varied in the range from 2.0 to 3.5 kg/cm^2 at an interval of 0.5 kg/cm^2. The volume of water discharged through the nozzle was collected in tank of 500 litre capacity. The system was operated to fill the tank and time to fill the tank was recorded. The maximum jet length of radius of throw is the maximum length of water sprayed by the raingun. It is directly measured by using the measuring tape from the raingun to the end of water throw. The data was recorded in three replications.

Pressure v/s discharge relationship: The pressure discharge relationships were developed between pressure and discharge by using four equations,

$Q = a_1 + b_1 P$, $Q = a_1 + b_1 P + c_1 P^2$, $Q = a_1 P^{b1}$ and $Q = a_1 e^{b1 P}$.

Where, Q = Discharge (lpm), P = Operating pressure (kg/cm^2) and a_1, b_1, c_1 = Constants of equations.

The regression coefficients were worked out for all the above equations and the equation with the maximum value of regression coefficient was chosen as the function for the relationship between discharge and pressure. The pressure discharge relationships were developed for 16 mm nozzle raingun at different riser heights.

Pressure v/s radius of throw relationship

The pressure radius of throw relationships were developed between pressure and radius of throw by using four equations, $R = a_1 + b_1 P$, $R = a_1 + b_1 P + c_1 P^2$, $R = a_1 P^{b1}$ and $R = a_1 e^{b1 P}$. Where, R = Radius of throw (m), P = Operating pressure (kg/cm^2) and a_1, b_1, c_1 = Constants of equations.

The regression coefficients were worked out for all the above equations and the equation with the maximum value of regression coefficient was chosen as the function for the relationship between radius of throw and pressure. The pressure radius of throw relationships were developed for 16 mm nozzle raingun at different riser heights.

Results and Discussions

Pressure discharge relationship

The variation in discharge of raingun with respect to the operating pressure of raingun was studied by developing the relationships between pressure and discharge of raingun. The effect of pressure on discharge of raingun for 16 mm nozzle is presented as below.

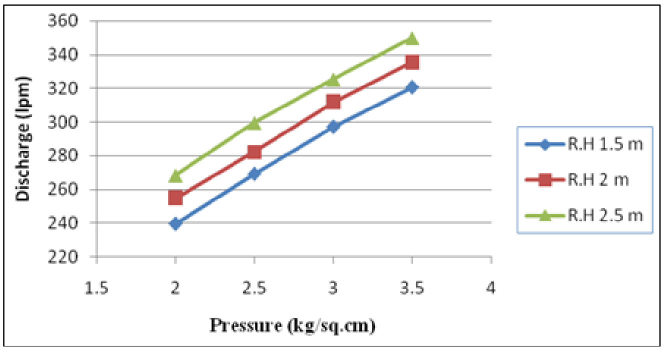

Fig 1: Relationship between pressure and discharge for 16 mm nozzle with jet breaker open at riser height of 1.5, 2.0 and 2.5 m

It was observed from Fig.1 that as the operating pressure increases, the discharge of the raingun also increases. The similar results were observed by other researchers (Aragade and Thombal, 1994 [1]; Muhammad *et al.* 2000 [4]; Javeer *et al*. 2005 [2]; Sonnar and Kapase, 2006; and Khedkar *et al.* 2014 [6]). As the riser height increases, the discharge also increases.

Therefore the relationship was developed between operating pressure of raingun with 16 mm nozzle and its radius of throw at different riser heights. The functions of the type linear, logarithmic, power, exponential, compound, inverse, growth and logistic curves were fitted between operating pressure (P) in kg/cm^2 and the discharge (Q) in lpm. The function that gave the maximum value of regression coefficient was chosen as the best fit among all the fitted functions. Among all the models the power type of function at 1.5 m riser height, linear function at 2.0 m riser height and power function at 2.5 m riser height fit the data well for 16 mm nozzle raingun when jet breaker is open as shown in Table 1.

Table 2: Relationship between the pressure (P) and discharge (Q) for 16 mm nozzle raingun at different riser heights with jet breaker open

Riser height (m)	Type of relationship	Equation	R^2
1.5	Power	$Q = 191.2P^{0.318}$	0.998
2	Linear	$Q = 27.14P + 200.9$	0.998
2.5	Power	$Q = 218.9P^{0.288}$	0.998

Pressure radius of throw relationship

The variation in radius of throw of raingun with respect to the operating pressure of raingun was studied by developing the relationships between pressure and radius of throw of raingun. The effect of pressure on radius of throw of raingun for 16 mm nozzle is presented as below.

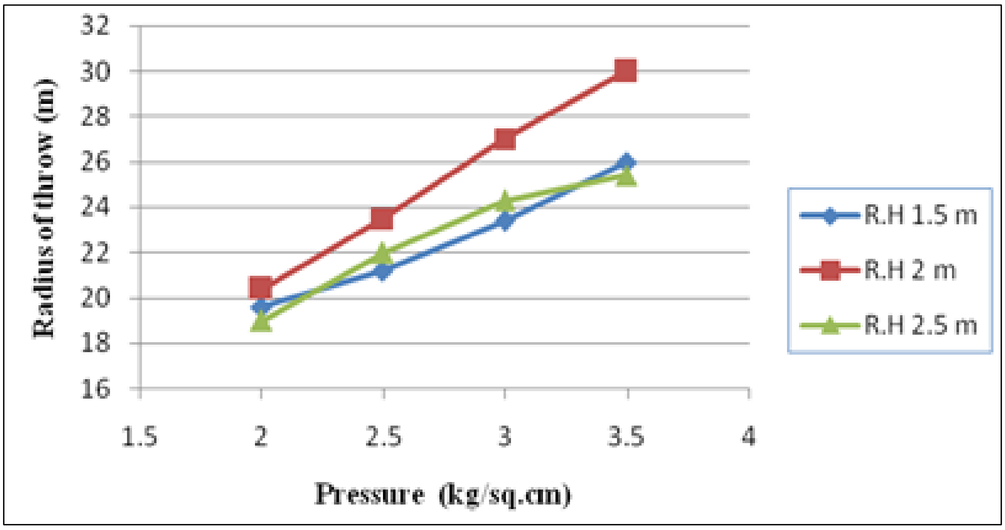

Fig 2: Relationship between pressure and radius of throw for 16 mm nozzle with jet breaker open at riser height of 1.5, 2.0 and 2.5 m

It was observed from Fig.2 that as the operating pressure increases, the radius of throw of the raingun also increases. The similar results were observed by other researchers (Aragade and Thombal, 1994; Muhammad *et al*. 2000; Javeer *et al*. 2005; Sonnar and Kapase, 2006; and Khedkar *et al.* 2014) [1, 4, 2, 6]. As the riser height increases, the radius of throw is also increases upto 2 m riser height and at 2.5 m riser height the radius of throw decreases when compared to 2 m riser height and nearer to the 1.5 m riser height.

Therefore the relationship was developed between operating pressure of raingun with 16 mm nozzle and its radius of throw at different riser heights. The functions of the type linear, logarithmic, power, exponential, compound, inverse, growth and logistic curves were fitted between operating pressure (P) in kg/cm^2 and the radius of throw (R) in m. The function that gave the maximum value of regression coefficient was chosen as the best fit among all the fitted functions. Among all the models the exponential type of function at 1.5 m riser height, linear function at 2.0 m riser height and logarithmic function at 2.5 m riser height fit the data well for 16 mm nozzle raingun when jet breaker is open as shown in Table 2.

Table 3: Relationship between the pressure (P) and radius of throw (R) for 16 mm nozzle raingun at different riser heights with jet breaker open

Riser height (m)	Type of relationship	Equation	R^2
1.5	Exponential	$R = 16.1e^{0.094P}$	0.995
2	Linear	R = 3.23P + 13.92	0.999
2.5	Logarithmic	R = 7.134ln(P) + 14.13	0.994

Conclusions

It is concluded that the discharge of raingun when operated standalone increase with operating pressure. This fact indicated the scope for deciding the operating pressure to obtain desired precipitation rate according to soil type. However the nature of variation of discharge with operating pressure is different for different makes of raingun. Similarly the radius of throw of raingun increased with operating pressure.

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