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PERFORMANCE EVALUATION OF DIFFERENT NOZZLES FOR ORCHARD WATER SPRAYING SYSTEM

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This study was' conducted to evaluate the perfonnance of circular, rectangular, double rectangular and triangular-shaped outlet nozzles to spray water on orchard trees. The circular nozzle was found better than rest of the three nozzle» in respect of discharge, effective area covered, application rate, coefficient of unifromity and distribution unrfonnity

Key words: orchard water spraying, outlet nozzles, performance evaluation

INTRODUCTION

Pakistan has great potential for the development of fruit industry due to suitability of soil and climatic conditions. Rainfall in Pakistan is neither sufficient nor does it has a regular pattern. The highest rainfall occurs during monsoon months, of July and August. The country on average receives 380-1270 mm of annual precipitation. The level of humidity is very low during the months of April, May and June. An important seasonal characteristic is that evaporation is much higher than precipitation making frequent artificial water spraying essential for some fruit plants. For example citrus fruit belongs to hot humid area, therefore during hot dry season it needs frequent spraying of water for proper development of fruit and good yield. It has been observed that after mid of April, in most part of Pakistan, atmospheric temperature rises abruptly. Rising temperature thus causes dropping of immature citrus fruit which has been reported to be one of the major reasons for low yield. Thus, spraying of (water upon fruit trees could help reduce environmental temperature and offered a control to the said problem.

Chen and Wallender (1985) have shown that by diffusing the spray jet, non-circular nozzles can be effective at lower operating pressure and may give an acceptable distribution. They also found that the sprinkler with non-circular nozzles decreased the droplet diameter. Li et al. (1994) compared different shaped nozzles in respect of droplet size distribution and reported significant effect of nozzle shape on the cumulative percentage of droplets less than 3mm dia. Li et al. (1995) evaluated the performance of double rectangular slot nozzles and found that pattern radius decreased as slot spacing increased and the same increased as the length to width ratio increased. They also reported that sprinkler pattern and droplet size were insensitive to the inside contraction angle. The nozzle discharge coefficient was independent of all the investigated parameters and sprinkler rotation speed' decreased with spacing but increased with the length to width ratio. Ahmad (1996) developed an adjustable height orchard water spraying system which required testing for different shapes of nozzles for their water spraying performance evaluation. Thus, the present study was undertaken to evaluate four types of locally designed nozzles which included circular. triangular, rectangular and double slot rectangular shapes.

METHODOLOGY

Fabrication of Nozzles: Orifice size, shape and operating pressure of nozzle plays critical role in its discharge. droplet size and uniformity. It was desired to develop a nozzle for citrus which should cover maximum area with uniform distribution of water and its maximum entrapmcnl by trees Therefore, triangular, rectangular and double rectangle slot nozzles with the same cross-sectional area and 20° inside contraction were developed at the Agricultural Mechaui zation Research Institute (AMRI), Multan. Pakistan. The dimensions of the said nozzles were: (i) circular n01Zle diameter of orifice, 18 mm; X-Sect. area, 255sq. nun. (iil triangular nozzle: lenght of three equal sides. 24 25 mill, magnitude of three equal angles, 60°; X-Sect area. 25'<; sq. mm, (iii) rectangular nozzle: length of slot. 24 nun: width of slot, 12.75 mm; X-Sect. area, 255 sq. mm and (iv) double rectangular slot nozzle: lenght of slot, 15 mm: width of slot, 8.5 mm; space between slots, 2mm;,X-Sect area. 255 sq. mm.

RESULTS AND DISCUSSION

Raingun was operated at 3.5 kg/cm' pressure with each type of nozzle i.e. circular, rectangular, double rectangular and triangular-shaped orifices. The data were used tocakillate the performance of various nozzles with reference to effect ivc-area covered, discharge, application rate and coefficient of uniformity. The results have been presented ill Table 1.

Effective Area Covered: The effective area covered was calculated from effective diameter of raingun. or \\hich coefficient of unifonnity was 80% or more. It can be SCCll from Table I that effective area was 2642. uno. 1662 and 1963 m? for circular, rectangular, double reetangul'" and triangular-shaped nozzles respectively at 3.~ kg/cm' pressure. These results showed that Circular nozzle gave higher effective area than the other three nozzles with almost the same coefficient of uniformity.

Table 1: Comparative performance of different nozzles

Nozzle shape	Circular	Rectangular	Double rectangular	Triangular
x-Sect. area (mm^2)	255	255	255	255
Operating pressure (kg/cm')	3.5	3.5	3.5	3.5
Discharge (l/s)	5.12	4.88	4.78	5.00
Effective radius (m)	29	24	23	25
Effective area (m')	2642	1810	1662	1963
Application rate (mm/hr)	6.97	9.71	10.36	9.17
Coefficient of uniformity (%)	82.03	~.70	80.26	~.83
Distribution uniformity (%)	75.94	75.57	75.20	76.41

Discharge: Discharge of each nozzle was measured on volumetric basis using calibrated metallic drum. The results showed that the discharge of circular, rectangular, double rectangular and triangular nozzles was 5.12, 4.88, 4.78 and 5.00 litres/second respectively. These results also indicated that circular nozzle gave higher discharge than the other nozzles under the same pumping pressure of 3.5 kg/cm'.

Application Rate: Application rate is the depth of water applied in a given time and is usually expressed in mm/hr. The application rate was calculated by using discharge and the covered wet area. Table 1 shows that the application rate was 6.97.9.11,10.36 and 9.17 mm/hr. for circular, rectangular, double rectangular and triangular nozzles recpectively at a pressure of3.5 kg/cm'. Application rate for double rectangular nozzle was the' highest, while it was the lowest for circular nozzle. It is important to mention here that effective area covered is a more desired parameter than the application rate. Actually. Iow application rate with circular nozzle happened to be due to the larger effective area covered. Thus the circular nozzle behaved better thatn the other nozzles.

Uniformity of Application: This parameter is calculated to evaluate the uniformity of application of the raingun using four different shaped nozzles. The results showed that coefficient of uniformity for circular, rectangular, double. rectangular and triangular-shaped nozzle was 82.03, 80.70, 80.26 and 80.83 respectively. The results revealed that circular-shaped nozzle gave the highest coefficient of uniformity.

Distribution Uniformity: The results showed that the distribution uniformity for circular. rectangular, double rectangular and triangular-shaped nozzles was 75.94, 75.57. 75.20 and 76.41% (Table 1) respectively within the range of effective radius. The distribution uniformity for triangular nozzle wa~ the highest, however, the difference among various nozzles was not significant v-c;

Since the corss-sectional area and cone angle/contracuou angle of each orifice was the same and all the nozzles were operated with the same gun at the same pressure. therefore. these parameters can be compared for selection or a suitable nozzle for spraying orchard. The results showed tluu circular nozzle discharge was the maximum, while double rectangular nozzle gave a minimum discharge among the four nozzles evaluated. This difference in discharge might be due to higher frictional losses. The discharge of circular nozzle was 9.5 lis, it covered the largest effective area (2642 m-) and gave the highest coefficient ofunifonnity (82.03 %). Similarly application rate for circular nozzle was 6.97 mm/hr.. while I'0' double rectangular nozzle it was 10.36 mm/hr. The high application rate was not desired as higher application rate ma~ damage the plants and fruits. This study was carried 0111 to modify aerial environment of citrus orchard instcad (If irri~a.. tion. Distribution uniformity of circular, rectangular: double rectangular. and triangular nozzles was 75.94. 75.57. 75.211 and 76.41 respectively. It may be seen that distribution llllifOlllil) of above mentioned four different shaped nozzles is comparable. Thus the ciruclar nozzle is proposed for further teslllg for fruit response.

Conclusion: The maximum value of coefficient of ullifoj'lI\il~ was abserved for circular nozzle' which was 82.05'% with 21) meters effective radius. The maximum distribution uniformity was observed for triangular nozzle which was *76A* I'~.,with 25 meters effective radius, while the distribution uniformity for circular nozzle was 75.94% with 29 meters effective radius. Circular nozzle was thus found better than .rest of the three nozzles in respect of discharge, effective area. application rate coefficient of uniformity and distribution uniformity Flirther evaluation is suggested of circular. rectangular. double rcctangular and triangular-shaped nozzles with reference to droplet size distribution at different pump pressures.

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