International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 8, Issue 53, 2016, pp.-2808-2810.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

VENTURI AIR INDUCTION NOZZLE CHARACTERISTICS FOR MOTORIZED KNAPSACK MIST BLOWER

BALACHAND C.H.[1*] AND SHRIDAR B.[2]

[1]Department of Agricultural Engineering, S.V. Agricultural College, Tirupati, 517 502, Acharya NG Ranga Agricultural University, Guntur, 522509, Andhra Pradesh
[2]Agricultural Machinery Research Center, Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India
*Corresponding Author: Email-chbalachand@rediffmail.com

Received: October 01, 2016; Revised: October 07, 2016; Accepted: October 08, 2016; Published: November 01, 2016

Abstract- One of the most essential components of motorized knapsack is the spray nozzle. This study evaluated the droplet spectrum of venturi air induction nozzle [available in the market] under various working pressures. In laboratory, droplet spectrum, using a droplet particle size analyzer and was measured with the operating pressure of 4500, 5000, 5500 and 6000 rpm. The results showed that: the droplet spectrum was affected by the nominal flow and by the liquid pressure. The motorized knapsack mist blower with venturi air induction nozzle gave the highest discharge of 1,842 ml min^{-1} at 4500 rpm and IV level of dosage. The NMD observed for different combinations of orifice sizes of 1.5 mm to 6.5 mm, were the droplet size increased from 15 to 21 µm respectively. The engine rpm from 5000, droplet size [VMD] increased from 88 to 139 µm with increasing the orifice size from 1.5 to 3.0 mm respectively. The uniformity coefficient for spraying jet nozzle is 5.6 to 7.4 with increasing the engine rpm from 4500 to 5000 rpm and decreases to 5.7 with increasing the engine rpm to 6000 rpm respectively.

Keywords- Spray Nozzle, Droplet Spectrum, Knapsack Mist Blower and Droplet Size

Citation: Balachand C.H. and Shridar B. (2016) Venturi Air Induction Nozzle Characteristics for Motorized Knapsack Mist Blower. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 8, Issue 53, pp.-2808-2810.

Academic Editor / Reviewer: Basavaraj Patil

Introduction

Motorized knapsack mist blowers are used extensively to apply pest control agents, especially on paddy, cotton, fruits and vegetables crops *etc.* Because of increasing costs for pest control agents and intensified concern for environmental protection, the needs for improvements in spray distribution and deposition efficiency are more critical than ever before. Ideally, air flow from knap sack motorized mist blower consume the minimum amount of energy needed to uniformly deposit the spray droplets throughout the target crop.

Motorized knapsack mist-blower are designed to produce a very fine spray or 'mist' [50-100 µm VMD droplets] and apply lower volumes than conventional knapsack sprayers, but most machines can also be adapted to apply granules and dusts [1]. These sprayers consist of a 35-70 cc two-stroke petrol engine, which drives a centrifugal fan. A large size engine is required to drive a fan with a greater output of air volume to spray taller trees for the emission of greater volume of air, which projects droplets higher than the small mist- blowers. It is rarely possible to project droplets higher than 10 m vertically even with the larger motorized knapsack sprayers.

[2] In order to evaluate spray coverage on tomato and citrus foliage the spray deposition on plant foliage with self-adhesive paper microscope slide labels were evaluated. These labels were attached to both upper and lower leaf surfaces throughout the plant canopy before spraying with a solution of brilliant blue dye [FD&C No. 1] as a tracer. The dye was subsequently eluted into vials of water and concentration of the reinstate determined spectrophotometrically. Spray coverage was also evaluated (comparing with similar sized squares of water-sensitive paper stapled onto leaves) by measuring dye concentrations on actual leaf surfaces which require sealing the other surface with cellophane tape.

[3] The droplet size and velocity distributions were studied by using an optical imaging pulsed laser system [the Oxford Lasers Ltd "Visi-Sizer"] at a distance of 350 mm below the nozzle tip. Measured spray fan angles of 110°, 80° and 65° of the nozzles. Droplet velocities were also higher with the smaller spray fan angles as expected with mean vertical liquid velocities of 7.16, 9.28 and 11.78 m s-1 for the 110°, 80° and 65° nozzles respectively when operating at a pressure of 3.0 bar. Increasing pressure, increased the droplet velocities with a 1.0 bar pressure change giving mean liquid velocity changes of between 12.4 and 15.6 per cent.

[4] The droplet diameter and droplet axial velocity from sprays generated were investigated by the air induction nozzles namely two flat fan nozzles and a twin flat fan nozzle. Phase Doppler Anemometry [PDA] measurements were carried out at various distances from the nozzle exit and the spray axis. Twin fluid with a flow rate Q and two single flat fan nozzles, one which, delivered Q, the other one Q/2. Measurements have shown that spray generated by the twin nozzle consisted in large fast droplets with a narrow size spectrum, which slowed very little, comparing to single nozzle. The flat fan nozzles with the Q flow rate generated more droplets [and faster droplets] than the nozzle with the Q/2 flow rate, although both nozzles showed approximately the same droplet sizes.

Keeping in view of the obvious advantages of air assistance to spray drop lets, it is necessary to quantify airflow patterns inside crop canopy determine the deposition of spray droplets on the plant leaves. But, a quantification droplet characteristic for different crops in field is difficult. Thus, a study was planned to observe the droplet characteristics under controlled condition.

Materials and Methods

Venturi Air Induction Nozzle

Air induction [AI] nozzles feature two orifices [Fig-1]. The first orifice, known as the pre-orifice, meters the liquid flow. The second orifice, known as the exit orifice, is larger than the pre-orifice and forms the spray pattern. There is a venturi between the two orifices. This air venturi draws air into the body of the nozzle where it is mixed with water. This mixing creates an air-entrained spray pattern at a lower pressure. The spray pattern is to contain of large, air-filled, coarse droplets with very few drift-susceptible droplets. Air is mixed into the spray solution within the nozzle. To fulfill the mixing, an inlet port and venturi is typically used to draw the air into the tip under reduced pressure. A larger spray droplet to help the droplets to reach the target in the form of air-fluid mixture. Spray drift is reduced by increasing the size of the spray droplet and minimizing smaller driftable fines. The current designs of these tips require a higher operating pressure to maximize the performance. This study was aimed to find out better operating conditions for venturi air induction nozzle. The venturi air induction nozzle was evaluated for their performance at different levels of engine speed and orifice diameter. The venturi air induction nozzle was tested four orifice diameter *viz.*, 1.5 mm, 3.5 mm, 5.0 mm and 6.0 mm and four engine speeds *viz.*, 4500, 5000, 5500 and 6000 rpm. In the laboratory, height of nozzle was maintained at 1 m from the ground surface. The droplet size was determined by measuring the diameter of circles formed by droplet deposited on silver bromide paper. Methelyne blue was added as dye solution to the chemical at the rate of 10 g lit^{-1}. The silver bromide paper of size 25 x 25 mm was used to collect the droplet samples produced at different engine speeds and orifice sizes combinations. The Dino-Lite Premier digital handheld microscope with 5 megapixel sensor was used to capture the images. The droplet images were digitalized and analyzed using the software developed with MATLAB.

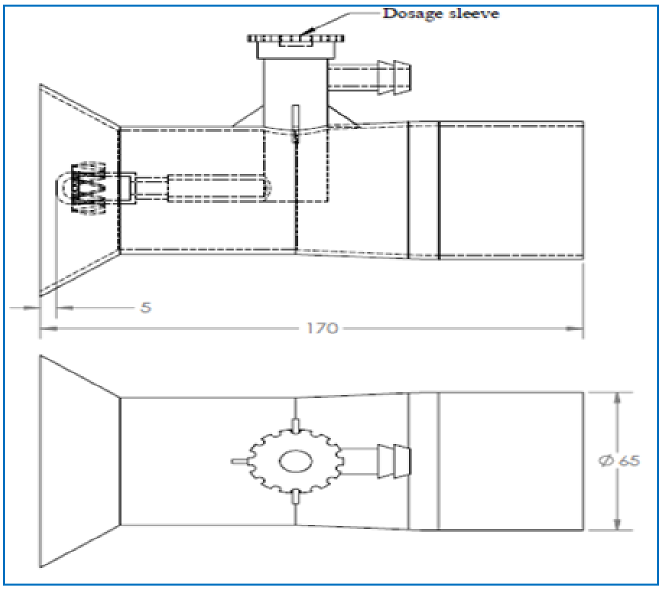

Fig-1 Venturi air induction nozzle

Measurement of discharge rate

The nozzles were tested using water as spray liquid. The discharge rate of the nozzles was tested for engine rpm ranges of 4500, 5000, 5500 and 6000. The spraying was done continuously and pressure was regulated to desired level. Sufficient time was allowed to bring the nozzle at constant discharge during this period, the discharge was diverted to a measuring cylinder and discharge obtained was clocked for given interval of time [5]. These values were expressed in terms of discharge per minute. Each nozzle was tested at three pressure and test was replicated thrice [6]. The values were present as engine rpm vs discharge.

Determination of droplet size

The droplet size was measured by measuring diameter of the circles formed by droplet deposition on a white photographic paper. 0.75 per cent w/w methylene blue was used as the dye solution. All the measurements were made at 500 mm from the nozzle along axis of spray for each nozzle. The droplet size is measured in micrometers [µm].The most widely used parameters to represent droplet size are the volume median diameter [VMD] and number median diameter [NMD] and VMD /NMD ratio.

Results and Discussion

Results of experiments conducted to study the effect of orifice diameter and engine speed on atomization characteristics of venturi air induction nozzle in motorized knapsack mist blower for different combination of factor levels are discussed here under the following headings.

Discharge rate study

The discharge rate of spray fluid at different orifice size and different engine speeds are given in [Table-1]. It shows that increasing orifice size from 1.5 mm to 6.0 mm resulted increase in discharge rate from 984 ml min^{-1} to 1,842 ml min^{-1} at 4500 rpm and 876 ml min^{-1} to 1,482 ml min^{-1} at 6000 rpm. It was also observed that the highest discharge rate was obtained in the venturi air induction nozzle with 4500-rpm engine speed. It can be observed that the discharge of venturi air induction nozzle was decreased from 4500 to 6000 rpm. This might be due to design characteristics and difference in process of atomization of liquid.

Table-1 *Discharge rate of Venturi air induction nozzle at different engine speeds and orifice sizes*

Engine speed, rpm / Orifice size, mm	4500	5000	5500	6000
1.5	984	978	1068	876
3.5	1170	1278	1482	1542
5.0	1584	1452	1524	1290
6.0	1842	1698	1758	1482

Droplet size study

The observed data for venturi air induction nozzle droplet size [NMD] is given in [Fig-2]. It is observed that the highest NMD is at engine speed of 5500 rpm and the lowest is at 4500 rpm. In all the trials, the lowest NMD is found in the orifice diameter of 1.5 mm only. The NMD for different combinations of orifice diameter of 1.5 mm to 6.0 mm, the droplet size ranges from 15 to 22 µm respectively. The NMD was found to increase as the orifice diameter was increased from 1.5 mm to 6.0 mm and slightly decreases as the engine speed increases from 5500 to 6000 rpm respectively. This may be due to increase in engine speed results more energy available for atomization of smaller number of droplets.

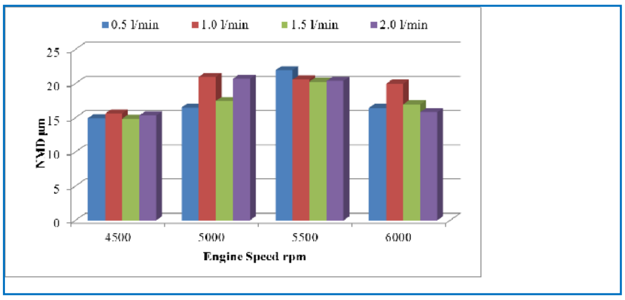

Fig-2 Number Median Diameter (NMD) of droplets at different orifice diameters and engine speeds

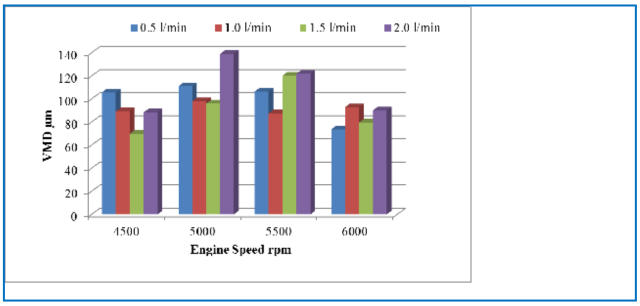

Fig-3 Volume Median Diameter (VMD) of droplets at different orifice diameters and engine speeds

[Fig-3] shows the data of VMD variation with engine speed and orifice diameter of venturi air induction nozzle. In all the experiments, the VMD was found to be more all the four orifice diameter. The lowest VMD observed in the 6000 rpm range in all the experiments. The highest droplet size [VMD] of 139 µm was found in 3.5 mm orifice size at 5000 rpm respectively. Because of venturi effect at the lowest engine speed, big sizes of droplets are formed.

The analysis of uniformity coefficient for 4500, 5000, 5500 and 6000 engine speeds for varying orifice diameters were presented in [Fig-4]. It was inferred that the highest uniformity coefficient for venturi air induction nozzle was 7.4 at engine speed 5000 for 3.5 mm orifice diameter. The orifice diameter 1.5 and 6.0 mm gave a consistent uniformity coefficient. The reason for changes in uniformity coefficient was at lesser speeds, the drag force is inadequate to spread the droplets and at higher speeds, the droplets may be drifted due to their lightness.

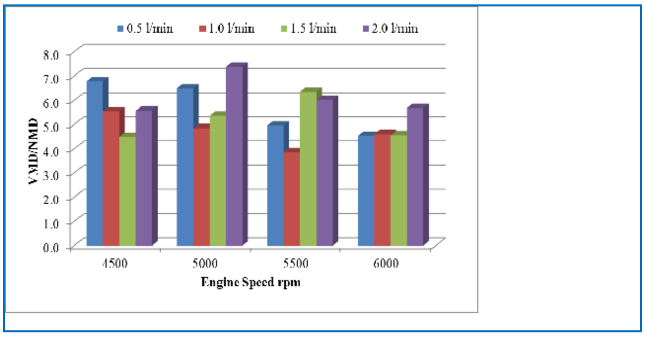

Fig-4 VMD/NMD ratio for different orifice sizes and engine speeds

Conclusion

The spray of the venturi air induction nozzle consists of more fine particles than the motorized knapsack mist blower nozzle. The discharge for venturi air induction nozzle increased from 984 ml min^{-1} to 1,842 ml min^{-1} at 4500 rpm for 1.5 to 6.0 mm orifice size and 876 ml min^{-1} to 1,482 ml min^{-1} at 6000 rpm for 1.5 to 6.0 mm orifice size. Venturi air induction nozzle droplet size [VMD] is 139 µm of 6.0 mm orifice diameter at 5000 rpm and NMD ranged from 15 to 22 µm. It was inferred that the uniformity coefficient was 7.4 at engine speed of 5000 rpm for 6.0 mm orifice diameter.

Conflict of Interest: None declared

References

[1] Bindra O.S. and Singh H. (1971) Pesticide application equipment. Published by Mohan Primlani, Oxford and IBH publishing Co., Delhi, pp: 61-157.
[2] Tong X.L., Stansly P.A. and Conner J.M. (2004) *Subtropical Plant Science,* 56, 39-43.
[3] Miller P.C.H., Butler Ellis M.C., Lane A.G., O'Sullivan C. M. and Tuck C. R. (2011) *Aspects of Applied Biology,* 106, 281-288.
[4] Ariane Vallet and Cyril Tinet (2012) Droplet Characteristics for Air Induction nozzles: Single and Twin flat fan nozzles. http://cigr.ageng2012.org/documentos/orales/O-PM.pdf: 168-173.
[5] Salyani M. and Serdynski J.W. (1993) *Applied Engineering in Agriculture,* 9 (1), 29-32.
[6] Ayers P.D., Rogowski S.M. and Kimble B.L. (1990) *Applied Engineering in Agriculture*, 6 (6), 701-706.