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PERFORMANCE TEST OF KNAPSACK MIST SPRAYER

by

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ABSTRACT

The knapsack mist sprayer is one of the pest control equipment that protect and exterminate the agricultural insects, weeds and others with using of liquid pesticides. So that it was chosen and this experiment was conducted to know the useful discharge rates on various metering, setting angle of blow pipe, to check the abilities of diffusion and penetration of pesticides and to research the effective swath width. In this paper, obtained result from the experiment were presented.

I. INTRODUCTION

In order to get more yield and high quality crop, it is necessary to protect the crop from the injury by insect, fungi and weed in the whole seasons of it's growing. One of the technical methods of this protecting is to use the pesticides and the application equipment although it comes up the over expenditures to the farm-houshold. However, it is sure that the yield by this pest control brings about the surplus of income at the harvesting time. The saving of labor in the pest control works is also an essential factor to decrease this expenditures while the using of application equipment of pesticides is the most effective method to this object.

The mist sprayer or mist blower is the application equipment of the pesticide mist which means the fine particle of liquid as small as 30-40 micron.

II. OBJECTIVE

The purpose of this field performance test of knapsack type mist sprayer is to ascertain the useful discharge rates on various metering, settings angle of blow pipe, to check the abilities of diffusion and penetration of pesticides with the air stream and to research the effective swath width and the deposit of pesticide on crop.

III. MATERIAL AND METHOD

1. Material

- Sprayer: Kioritz DMD 4600-23 sprayer was used during the experiment. The sprayer is mounted on a knapsack frame which is carried on the operator's back and has an engine-driven blower to produce high velocity air stream into which the pesticide is metered. The air flow generated in the blower is led to the top of liquid tank to feed the liquid. Thus, the pesticide liquid discharges out to the blow head with the stable condition while the slit of the cock adjusts the discharge rate.

- Chemical: Water and red dye
- Equipments:
  1. Anemometer, to measure the wind speed,
  2. Rigid stand, to use the discharge performance test,
  3. Slant rule, to use the discharge performance test,
  4. Measuring cylinder, to measure amount of water,
  5. Pitot-tube and manometer, to measure air velocity,
  6. Tachometer, to measure revolution,
  7. Steel rule,
  8. Sampling papers, to check the deposit, length is 4 cm and width is 3 cm,
  9. Wooden poles, to support the sampling papers,
  10. Stop watch, to check the traveling speed and to measure the discharge rate,
  11. Profile projector, to measure the particle size,
  12. Sound level meter, to check the noise level.

2. Method

2.1 Researching of Construction

The test is to confirm the principle, the structure and the dimension of the test sprayer.

2.2 Discharge Performance Test

The test sprayer is mounted on the rigid stand and a level mark near the top of tank was made. The time for discharging water from the marked level or the transparent tank was measured and the water in measuring cylinder was refilled to the marked level after the stop of spraying, so that the discharge rate **q** is,

$$\dot{q} = 60 * D / T$$

where is;

q = discharge rate (L/min)
D = discharge (L)
T = time (s)

Measuring time of one test is 1 minute and the number of test is 3 times. The revolution of sprayer was set at the maximum. The angle of blow head was set at 10° and 30° downward angle against the horizontal level. The variation of discharge rates between the levels of filling (95% of capacity) and near empty (20% of capacity) in tank was checked by using water.

2.3 Blower Performance Test

The test was done with utilization of a pitot tube, a manometer and a tachometer in the respective condition and the measuring position of pitot tube was 10, 30 and 50 cm far from the tip of blow head along the air stream which is discharged from the blow head. As the value of pressure head on the manometer was chosen the maximum in each position, under condition in which the revolution of blower is maximum and the discharge of liquid was closed. A formula to count the velocity from the head is as follows;

$$V = 4 * (h)^{1/2}$$

where is;
V = Velocity (m/s)
h = Measured head (mmAq)

2.4 Spray Performance Test

The test was conducted on the plain field of length 30 m and width 21 m (Fig.1). The diffusion type and straight type of blow head was selected and the application rate and the traveling speed, was decided to 300 L/ha and 0.3 m/s respectively, with a swath width of 5 m and a discharge rate 2.5 L/min. Before and during each test the wind velocity was measured by the anemometer, which should not be over 1 m/s. The mixture of water and red dye (0.5 % by weight) were used to check the deposit on the sampling paper. The sampling paper was cut 4 cm length and 3 cm width. One trained operator was employed to perform this test. The traveling speed was kept constant at 0.3 m/s. The divided distance along with a traveling direction and the passing time for each distance were provided to keep the constant traveling speed in the field and the forms of spraying are the both side of left and right and swing application. The deposit rate was measured by the comparison with the Deposit Standard. The effective deposit width was decided more than 3 of Deposit Standard. An effective swath was meant a range of effective deposit. Sizes of particles caught in the silicon oil (viscosity: 10000 cSt) on slide glass were measured with the profile projector. The slide glass was put at the center of swath on the same height as the sampling paper. As the representative diameter, the diameters corresponding to 50 % of the cumulative volume diameter (VMD,

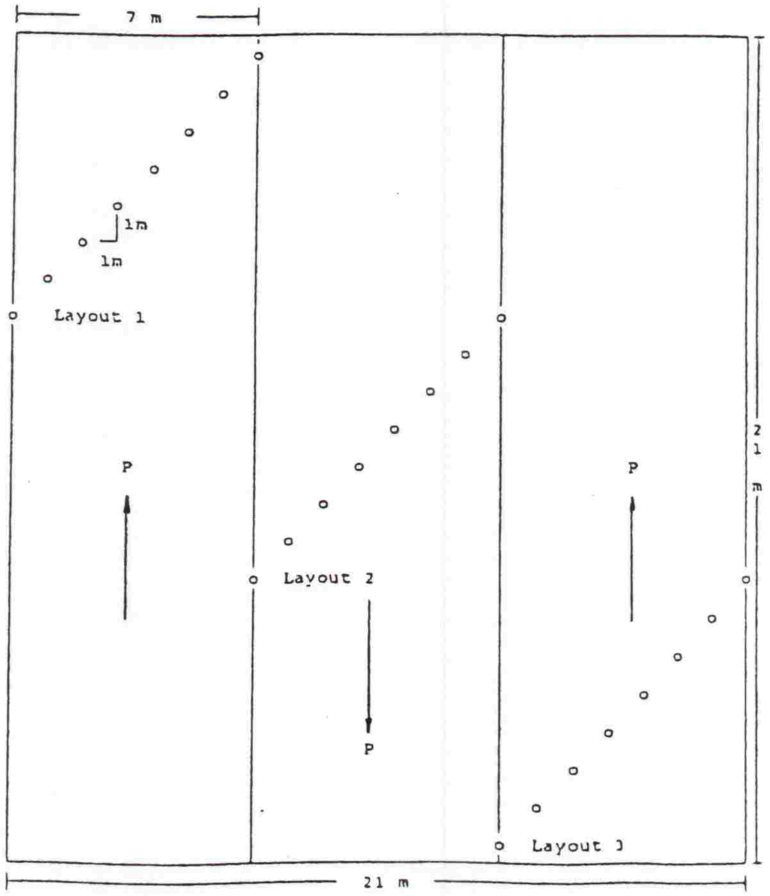

Fig.1 Layout of Field

volume medium diameter) are calculated and shown with the distribution of sizes of particles in the tables and figures. The presentation of particle size blown out from the blow head was shown by the VMD.

2.5 Noise Level Test

The noise at the operator's ears level was measured by using sound level meter at the maximum revolution of blower and maximum discharge rate of water. The noise level should be less than 90 dB at the operator's ears.

IV. RESULTS

1. Construction

1. Name and type of machine: KIORITZ DMD 4600-23
2. Dimension:
   - Overall length: 390 mm
   - Overall width : 505 mm
   - Overall height: 680 mm
3. Engine:
   - Number of cycle: 2
   - Number of cylinder: 1
   - Cooling system: Air
   - Displacement: 44 cc
   - Maximum power: 2.65 PS (1.9 kW)
   - Maximum revolution of shaft: 9000 rpm
   - Kind of fuel: Gasoline mixed with oil (25:1)
   - Starting method: Recoil starter
4. Blower:
   - Type: Centrifugal
   - Direction of shaft: Horizontal
   - Coupling method to engine: Direct
5. Liquid tank:
   - Capacity: 10 L
   - Agitation: No agitation
6. Liquid feeding and metering:
   - Feeding system: Air compress from tank to nozzle by blower and head difference between liquid and nozzle
   - Metering system: Opening of valve
   - Number of adjusting set: 4

2. Data Sheet of Liquid Discharge Rate

Nozzle Type: Diffusion

Angle of blow head (°)	Tank filling (%)	Accel. level	Engine rev. (rpm)	Set of metering	Discharge rate (L/min)
10	95	4	7100	1	0.99
				2	1.54
				3	2.34
				4	3.20
10	20	4	7100	1	0.80
				2	1.41
				3	2.17
				4	2.71
30	95	4	7400	1	1.24
				2	2.02
				3	3.18
				4	4.11
30	20	4	7400	1	1.15
				2	1.87
				3	2.87
				4	3.97

Nozzle Type: Straight

Angle of blow head (°)	Tank filling (%)	Accel. level	Engine rev. (rpm)	Set of metering	Discharge rate (L/min)
10	95	4	7500	1	0.95
				2	1.60
				3	2.51
				4	3.17
10	20	4	7500	1	0.81
				2	1.44
				3	2.22
				4	3.13
30	95	4	7500	1	1.23
				2	2.08
				3	3.15
				4	4.23
30	20	4	7500	1	1.11
				2	1.86
				3	2.92
				4	3.96

3. Data Sheet of Air Velocity

Type of blow head	Accel. level	Measuring Position (cm)	Measured H1 mmAq	H2 mmAq	Head H mmAq	Air Velocity (m/s)
Diffusion	4	10	773	726	47	30.35
		30	762	738	24	21.69
		50	755	746	9	13.28
Straight	4	10	795	705	90	42.00
		30	773	726	47	30.35
		50	757	745	12	15.34

4. Data Sheet of Effective Swath Width

Measuring Point No	Deposit rate by Deposit Standard			
	Layout no of Field 1	2	3	Average
Diffusion type nozzle, metering: 2				
1	1.50	1.25	1.75	1.50
2	4.00	3.75	3.75	3.80
3	4.00	2.75	3.50	3.42
4	3.25	3.75	3.00	3.33
5	4.50	5.00	3.00	4.17
6	3.25	2.75	3.50	3.17
7	5.00	5.00	2.00	4.00
8	1.25	1.25	2.75	1.75
Diffusion type nozzle, metering: 3				
1	0.00	1.00	1.75	0.92
2	4.00	2.25	3.50	3.25
3	4.25	4.00	4.00	4.08
4	4.50	3.25	4.75	4.17
5	3.00	4.75	3.50	3.75
6	4.00	4.25	4.75	4.33
7	5.00	4.25	4.75	4.67
8	3.25	4.00	3.00	3.42

Straight type nozzle, metering: 2

1	2.50	2.25	3.00	2.58
2	3.50	3.75	3.25	3.50
3	3.75	2.50	4.50	3.58
4	3.00	2.25	4.25	3.17
5	4.50	3.00	3.75	3.75
6	4.25	4.50	3.75	4.17
7	4.75	3.25	4.75	4.25
8	1.25	3.25	2.25	2.25

Straight type nozzle, metering: 3

1	3.00	3.25	4.00	3.58
2	5.00	4.25	3.75	4.33
3	3.00	3.75	3.75	3.50
4	3.75	4.25	4.50	4.17
5	3.75	4.25	3.75	3.92
6	4.25	3.50	4.50	4.08
7	5.00	5.00	4.75	4.92
8	3.00	4.50	3.00	3.50

4.5 Data Sheet of Particle Distribution and Calculation VMD

Diameter of particle (d)	Number of particle (n)	n*d3 (micron3)	Cumulative n*d3 (micron3)	Percentage of cumulative (%)	VMD micron
Diffusion type nozzle, metering: 2					
25	20	312500	312500	0.09	
50	44	5500000	5812000	1.65	
75	27	11390625	17203125	4.89	
100	35	35000000	52203125	14.85	
125	22	42968750	95171875	27.07	
150	21	70875000	166046875	47.22	160
175	6	32156250	198203125	56.37	
200	11	88000000	286203125	81.39	
225	3	34171875	320375000	91.11	
250	2	31250000	351625000	100.00	
275	0	0	351625000	100.00	

Diffusion type nozzle, metering: 3

25	5	78125	78125	0.05	
50	17	2125000	2203125	1.38	
75	19	8015625	10218750	6.41	
100	23	23000000	33218750	20.85	
125	8	15625000	48843750	30.66	
150	9	30375000	79218750	49.73	160
175	4	21437500	100656250	63.19	
200	2	16000000	116656250	73.23	
225	1	11390625	128046875	80.38	
250	2	31250000	159296875	100.00	
275	0	0	159296875	100.00	

Straight type nozzle, metering: 2

25	6	93750	93750	0.09	
50	11	1375000	1468750	1.45	
75	17	7171875	8640625	8.53	
100	7	7000000	15640625	15.44	
125	5	9765625	25406250	25.08	
150	5	16875000	42281250	41.74	180
175	0	0	42281250	41.74	
200	4	32000000	74281250	73.33	
225	1	11390625	85671875	84.58	
250	1	15625000	101296875	100.00	
275	0	0	101296875	100.00	

Straight type nozzle, metering: 3

25	10	156250	156250	0.05	
50	12	1500000	1656250	0.58	
75	14	5906250	7562500	2.65	
100	18	18000000	25562500	8.97	
125	9	17578125	43140625	15.15	
150	10	33750000	76890625	26.99	190
175	3	16078125	92968750	32.64	
200	8	64000000	156968750	55.11	
225	0	0	156968750	55.11	
250	3	46875000	203843750	71.56	
275	0	0	203843750	71.51	
300	3	81000000	284843750	100.00	

V. CONSIDERATION

1. Liquid Discharge Rate

Fig.2 and Fig.3 show the discharge rates of diffusion and straight type nozzle when the tank was filled to 95 % and 20 % with water, at an angle of blow head 10° and 30° and the metering of 1 to 4. Among those, the factor giving strong effect on discharge is the opening of metering and the inclination angle of the blow head is next. The rate of tank filling gives less influence. When the set of metering is increased from 1 to 4, discharge rate also gradually increased under the same condition. The discharge rate of mist sprayer is not always constant during application. So the checking of discharge rate before the application is necessary to keep the even deposit in the field on using this sprayer.

2. Air Velocity

Fig.4 shows that air velocity of two different type of nozzles. Air velocity is gradually decreased when the distance of measuring position to the tip of blow head is increased to 10 cm, 30 cm and 50 cm respectively. In case of the straight type nozzle, air velocity is greater than diffusion type nozzle.

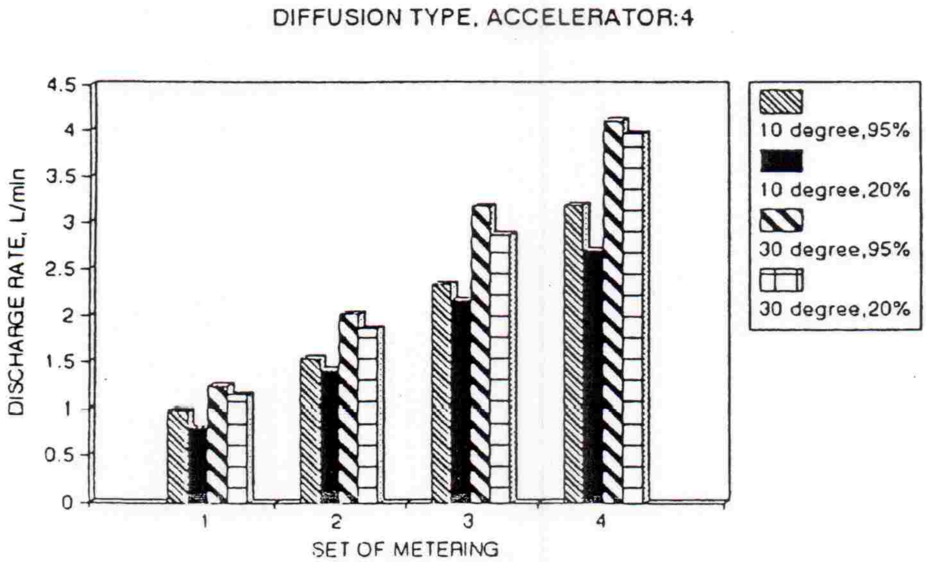

Fig.2 Discharge Rate of Diffusion Type Nozzle

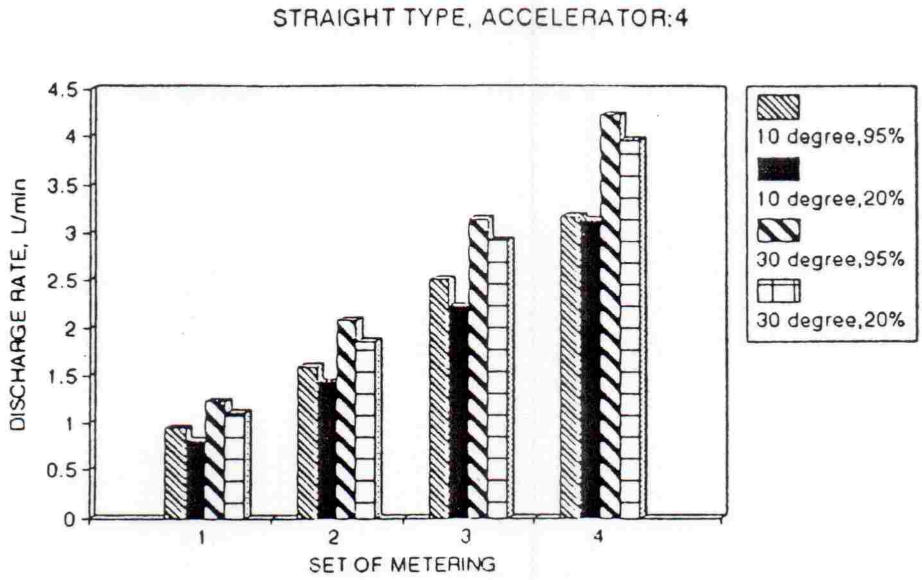

Fig.3 Discharge Rate of Straight Type Nozzle

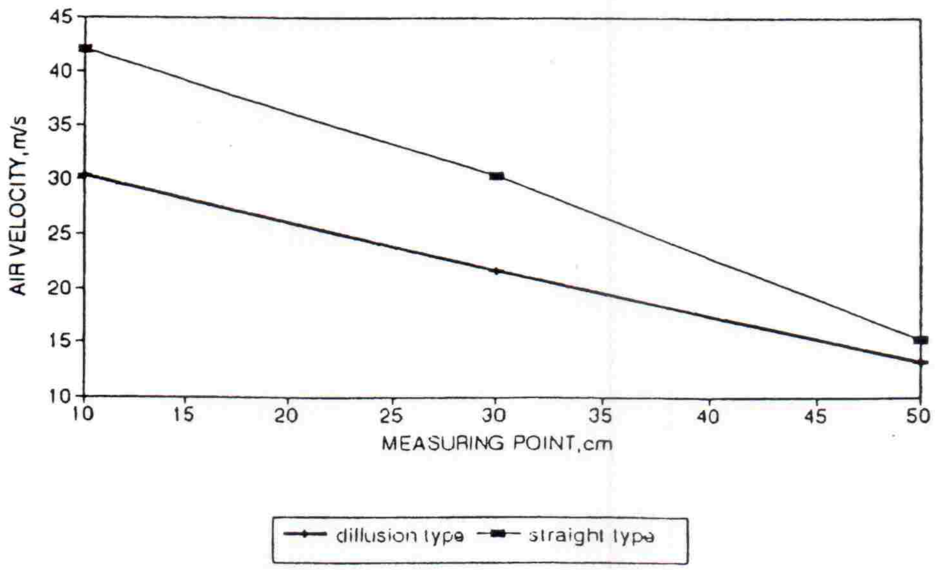

Fig.4 Air Velocity

3. Effective Swath Width

Fig.5 shows that the effective swath width is around 6 m for both nozzle type. But deposit rate by Deposit Standard vary from 1 to 5. This means that liquid is not equally deposited on the different places of the test field. The swinging of blow pipe to right and left produces the unevenness deposit on the target of the pest control so that the high speed of swinging of blow head and the high speed of traveling in field is not profitable.

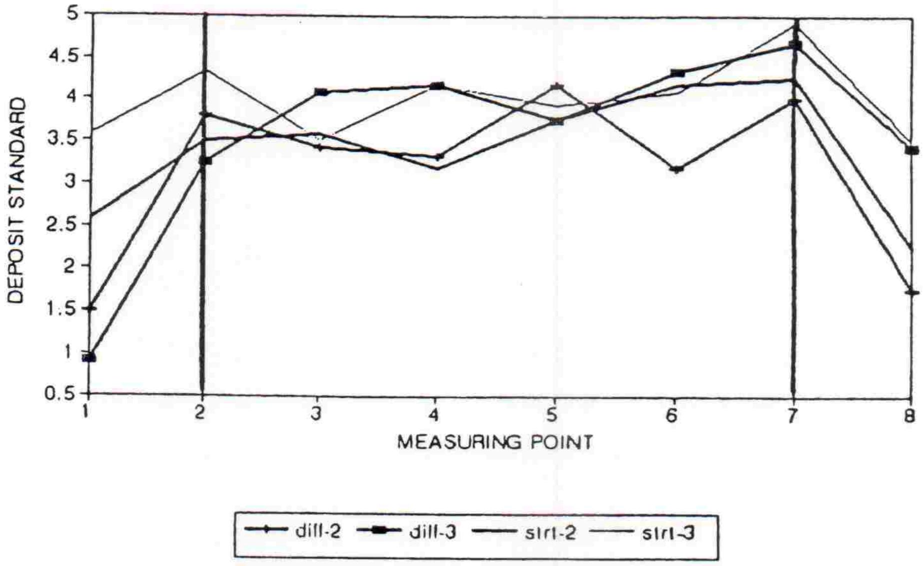

Fig.5 Effective Swath Width

4. Particle Distribution

Fig.6, Fig.7, Fig.8 and Fig.9 show that particle diameter varies from 25 micron to 300 micron and number of particles are mostly densed between 25 and 200 micron. From the graphs, VMD value for different type of nozzle and different level of metering can be obtained as 160, 160, 180 and 190 micron respectively.

5. Noise Level

Noise level was obtained 92-96 dB at a distance of 5 m from sprayer and 103-107 dB at the operator's ear level. Even though this test was carried out at maximum accelerator level, noise of the operator's ear level may be not desirable.

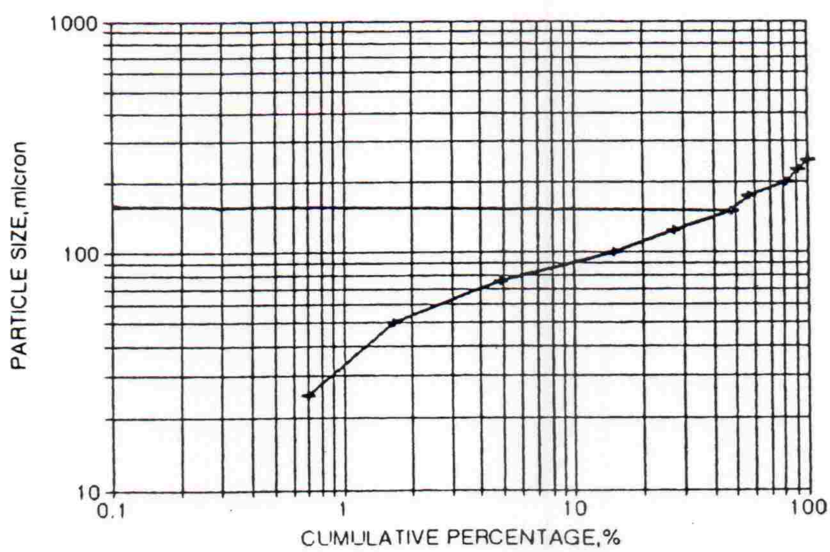

Fig.6 Particle Distribution of Diffusion Type Nozzle (Metering:2)

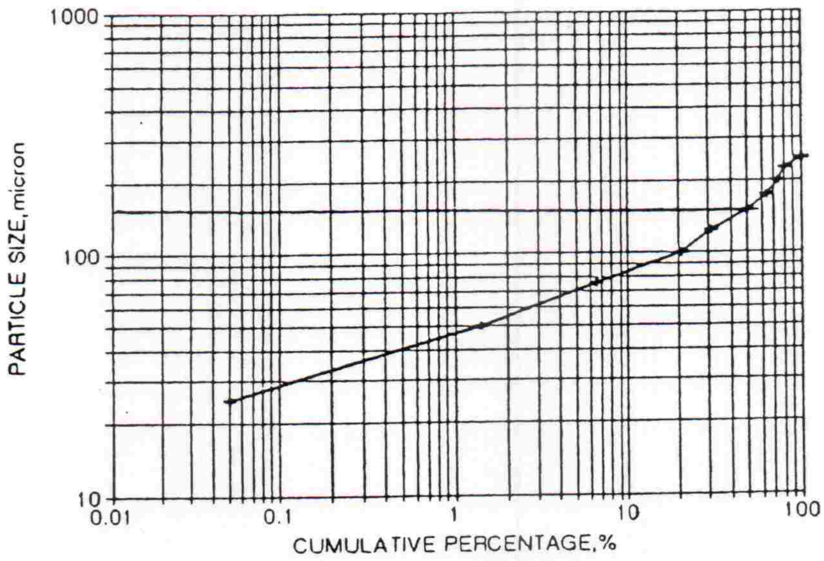

Fig.7 Particle Distribution of Diffusion Type Nozzle
(Metering:3)

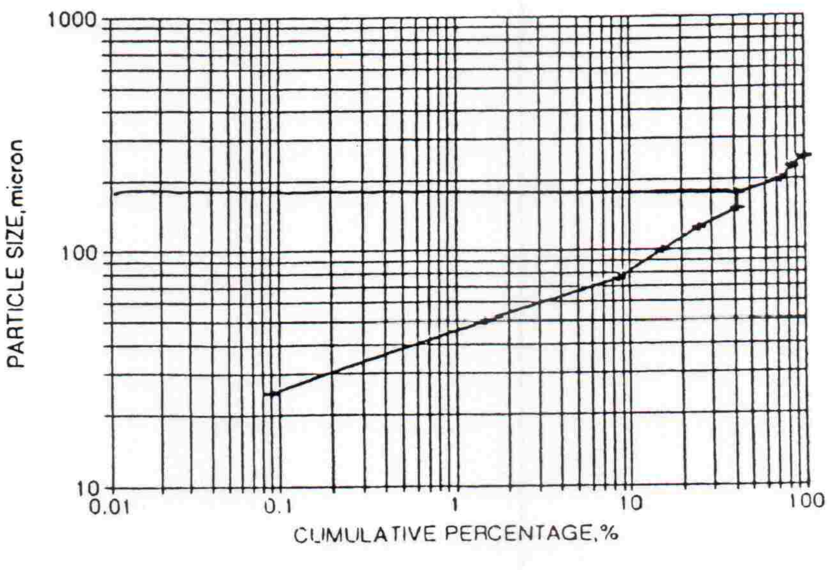

Fig.8 Particle Distribution of Straight Type Nozzle
(Metering:2)

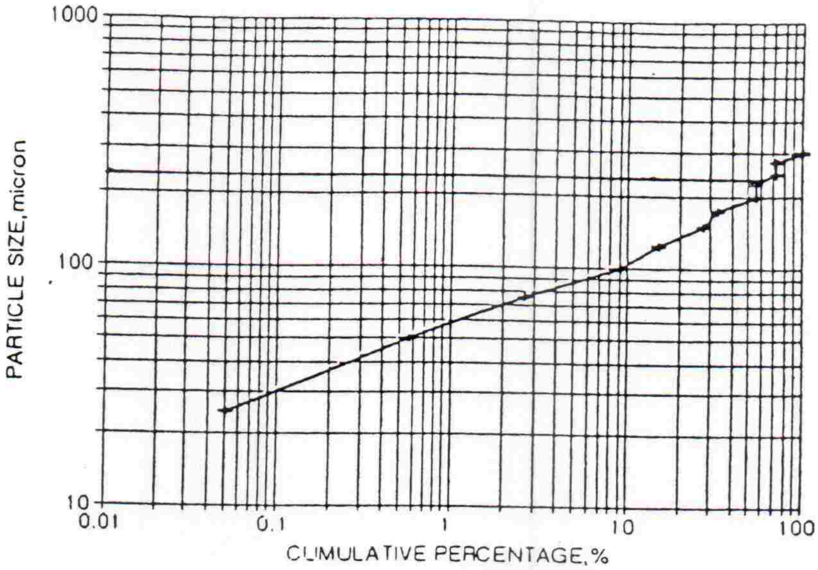

Fig.9 Particle Distribution of Straight Type Nozzle (Metering:3)

VI. CONCLUSION

As a developing country, Turkiye already has the experience of using knapsack mist sprayer. Especially for small scale farms, this type of sprayer is very useful and effective for prevention of pest and other diseases. So that, to study the knowledge of application equipment with its techniques is the most important to perform the effective application works. As a consequence it was a very good opportunity to conduct this test and evaluate its results for better application in future.

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