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Effect of Constant Flow Valves on Performance of Pesticide Sprayers

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ABSTRACT

In Pakistan, Knapsack and tractor mounted boom sprayers are mostly used to spray pesticides onto crops. A major problem with these sprayers is the specified nozzle pressure which does not remain constant during spray. This leads to loss of pesticide due to dribbling/drift during application. These phenomena not only add to cost of production but also cause environmental pollution and imbalance in natural echo system. To combat these problems, three sets of Constant Flow Valves were used with nozzles of Knapsack and boom sprayers. The valves gave very encouraging results in terms of maintaining uniform nozzle pressure and discharge and 2 to 3 times decrease in physical fatigue required to operate Knapsack sprayers. Constant Flow Valves are cheap and can easily be attached with the conventional sprayers, so their use among the farmers should be promoted.

Key Words: Sprayers; Constant Flow Valves; Nozzle discharge/pressure; Environment pollution; Cotton

INTRODUCTION

In Pakistan, cotton farming is an occupation of 1.5 million families and provides job to 54% of the labour force (Ahmad & Makhdum, 1992). However, the yield (641 kg/ha) is very low as compared to many other cotton producing countries of the world (Economic Survey of Pakistan, 2000-2001). One of the major factors for such a low yield is inefficient control of insect/pests on the crop for which Pakistan is spending over 4.4 billion rupees annually. About 70% of the total pesticides consumed in the country is sprayed onto cotton crop to cover about 80% of total cotton crop area (GOP, 2000).

According to Census of Agricultural Machinery (1994), about 21000 boom sprayers are being used in the country. Trials conducted by Central Cotton Research Institute, Multan, Pakistan, indicated that about 50% of the pesticides applied to different crops is wasted during application which not only adds to the cost of production but also causes environmental pollution hazards and imbalance in the natural echo system (Rehman, 1994). Two major reasons for pesticide loss are unawareness of farmers and use of inefficient pesticides application machinery (Mathews, 1988). Several different types of sprayers such as tractor mounted sprayers, power mist blower/duster, Knapsack power hydraulic sprayer, Knapsack manually operated compression sprayer, Knapsack manually operated hydraulic sprayer, self propelled high clearance boom sprayer, etc are being used for pesticides application. Most of the farmers in Pakistan have a small land holding, so they use conventional man-operated hydraulic knapsack sprayers for pesticides application. The farmers/operators, cannot maintain the required number of strokes per unit time and the specified operating pressure due to which the spray distribution and droplet size are not uniform. To overcome these problems Constant Flow Valves (CFVs) were tested with knapsack and boom type sprayers in the laboratory with the following objectives

1) To study the effect of increased pump pressure on nozzle flow rate and pressure with and without constant flow valves for hand and boom type sprayers.
2) To study the physical effort required to operate pump of hand sprayer with and without constant flow valves.

MATERIALS AND METHODS

The performance CFVs were tested at the Sprayer Testing Laboratory of Agricultural Mechanization Research Institute (AMRI), Multan. The CFVs are colour coded as Red, Blue and Green which are rated for 24, 30, and 45 psi pressure. The valves are 51 mm long and 33 mm in diameter. They consist of a throttle pin, spring and diaphragm which are molded in high quality plastic material. The valves were tested with hollow cone nozzle which was rated for 0.8 L/min flow rate at 45 psi (3 bar) pressure. Hudson manually operated hydraulic Knapsack sprayer was used to check the effect of CFVs on the performance of hand sprayer. The test was conducted on Sprayer Endurance Test Bench which was developed to meet the specifications of Pakistan Standard Institute (PSI), Karachi. The Sprayer Endurance Test Bench was operated with the help of a 0.25 h.p variable speed electric motor to attain the desired number of pump strokes. Pressure gauges were used to measure pump and nozzle pressures separately. A cylinder of 500 mL capacity and a stop watch were used to record flow rate of the nozzle. To increase the pump pressure, the number of pump strokes were increased accordingly. Sprayer tests were conducted with and without

Constant Flow Valves. Each test was repeated thrice to obtain average flow rate and nozzle pressure for different pump pressures.

The test for boom type sprayer was conducted on Wear Test Bench equipped with six nozzles. Pressure gauges installed both at the pump and nozzles were used to record pump pressure and the operating pressure of each nozzle. A three plunger pump capable of producing 25 kg/cm^2 (about 370 psi) pressure equipped with pressure gauge and pressure regulator was used to provide inlet pressure. Red, Blue and Green constant flow valves were tested against 30, 40, 50, 60, 70, 80, 90 and 100 psi pump pressures to record operating pressure and flow rates of different nozzles. The tests were repeated thrice to obtain average pressure and flow rates of nozzles.

Effect of installing CFVs on physical effort or operator's fatigue was studied by counting a number of pump strokes required to spray a given distance with a hand sprayer. In order to count the number of pump strokes to spray a given distance, a span of 200 feet (61 m) was selected and the same was sprayed with and without constant flow valves installed on the sprayer. The number of pump strokes required to spray a span of 200 feet were counted and the test was repeated for three times to obtain average number of strokes.

RESULTS AND DISCUSSION

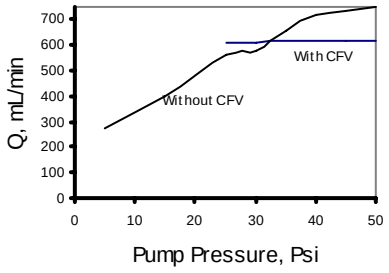
Effect of CFVs on Knapsack sprayer. The data regarding the effect of increasing pump pressure on nozzle flow rate and operating pressure with and without constant flow valves is given in Table I. Three CFVs were tested with a hollow cone nozzle rated for 0.8 L/min at 45 psi pressure. The results of the table show that the nozzles worked at the specified pressure of CFVs even though the pump pressure was increased from 5 to 50 psi. This phenomenon helps to control drift of pesticides from targeted area and consequently avoid environmental pollution of non targeted areas. It is interesting to note that the sprayer nozzle did not work at all when pump pressure was less than the specified pressure of Constant Flow Valves. This indicated that CFVs helped to save pesticides from being lost to the ground surface which may otherwise go wasted as a result of coarse spray particles and dribbling of nozzles at low pressures. Pesticide moved to ground surface may contaminate the soil environment or make its way to surface/groundwater resources with irrigation or rainfall water. By controlling drift/dribbling by using CFVs, farmers would not only save the costly pesticide but also the surrounding environment of their farms and dwellings.

Further analysis of data contained in Table I indicated that the nozzle discharge when equipped with CFV did not change to a greater extent with the increase of pump pressure. Whereas, nozzle discharge without CFV did increase from 270 to 750 mL/min (about 2.5 times) when pump pressure was increased from 5 to 50 psi. For better understanding, the nozzle discharge with Red CFV and without CFV is compared in Fig. 1. The curve for without CFV depicts almost a linear increase in the nozzle discharge with increase in pump pressure; whereas, a uniform discharge of about 615 mL/min was observed for Red CFV. Other two valves (Blue and Green) did not operate the nozzle when pump pressure was less than their specified pressures (30 & 45 psi) whereas the Red valve performed better at all pump pressures ranging from 25 to 50 psi. The discharge of nozzle with Red valve at low pump pressures (25 to 35 psi) better agreed with rated nozzle discharge of 800 mL/min when compared without CFV nozzle discharge. From the discussion, it may be concluded that Red Constant Flow Valve should be used with Knapsack sprayers in order to spray close to the rated nozzle discharge at low pressures which will reduce operator's fatigue.

Table I. Effect of increased pump pressure on nozzle pressure (P) and discharge (Q) with and without CFVs for Knapsack sprayer

Pump Pres. Psi	RED		BLUE		GREEN		Discharge without CFVs, mL/min
	P	Q	P	Q	P	Q	Q
5	-	-	-	-	-	-	270
15	-	-	-	-	-	-	395
25	23	610	-	-	-	-	560
30	23	610	-	-	-	-	580
35	23	615	30	695	-	-	660
40	23	615	30	705	-	-	720
45	23	615	30	705	45	520	735
50	23	620	30	710	45	540	750

Fig. 1. Effect of pump pressure on nozzle discharge with and without constant flow valve (CFV) for hand sprayer



Effect of CFVs on boom type sprayer. Data regarding the effect of increasing pump pressure on nozzle flow rate and operating pressure for boom type sprayer is given in Tables II, III and IV. The results of Table II show that when Red valve was used with one nozzle, it gave constant flow rate of 635 mL/min and nozzle pressure of 22 psi and when it was used with two nozzles, a slight decrease in flow rate and nozzle pressure was observed. When the same valve

was used with three and four nozzles at a time, the flow rate decreased to 560 mL/min and pressure to about 18 psi. The flow rate with Red valve did not match with the rated flow rate of nozzle i.e. 800 mL/min. This indicated that the Red valve is not appropriate for sprayers having more than one nozzle. A similar behavior was observed for Blue constant flow valve (Table III). An average flow rate of about 715 mL/min at 30 psi pressure was observed for single nozzle fitted with Blue valve. When the same valve was tested with four nozzles, the flow rate dropped to a minimum value of 550 mL/min and pressure to 24 psi. The Blue valve when

Table II. Effect of increased pump pressure on discharge of different nozzles of boom type sprayer equipped with red valve

PP (psi)	AFR1 (mL/ min)	AFR2 (mL/min)		AFR3 (mL/min)			AFR4 (mL/min)			
		Q1	Q2	Q1	Q2	Q3	Q1	Q2	Q3	Q4
30	633	580	580	537	544	560	527	524	527	538
40	634	600	590	540	550	567	567	578	550	540
50	634	620	590	554	555	567	567	584	554	547
60	635	633	600	560	557	570	567	587	564	550
70	635	627	594	560	560	574	565	584	570	574
80	635	630	600	563	560	570	567	588	570	580
90	634	633	610	567	557	574	570	587	570	582
100	635	630	610	570	560	577	569	588	570	584

PP= Pump pressure; AFR1= Average flow rate for one nozzle; AFR2= Average flow rate for two nozzles; AFR3= Average flow rate for three nozzles; AFR4= Average flow rate for four nozzles

Table III. Effect of increased pump pressure on discharge of different nozzles of boom type sprayer equipped with blue valve

PP (psi)	AFR1 (mL/ min)	AFR2 (mL/min)		AFR3 (mL/min)			AFR4 (mL/min)			
		Q1	Q2	Q1	Q2	Q3	Q1	Q2	Q3	Q4
30	-	-	-	-	-	-	-	-	-	-
40	710	620	705	600	665	665	550	667	660	680
50	717	624	707	600	670	670	554	670	664	687
60	716	630	707	604	674	677	554	670	667	694
70	719	637	714	614	680	680	560	680	667	690
80	719	637	717	614	677	680	564	680	668	700
90	718	637	718	617	674	680	560	680	670	700
100	719	637	718	620	670	682	564	680	670	700

PP= Pump pressure; AFR1= Average flow rate for one nozzle; AFR2= Average flow rate for two nozzles; AFR3= Average flow rate for three nozzles; AFR4= Average flow rate for four nozzles

Table IV. Effect of increased pump pressure on discharge of different nozzles of boom type sprayer equipped with green valve

PP (psi)	AFR1 (mL/ min)	AFR2 (mL/min)		AFR3 (mL/min)			AFR4 (mL/min)			
		Q1	Q2	Q1	Q2	Q3	Q1	Q2	Q3	Q4
30	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-
60	898	770	887	784	857	840	754	807	787	787
70	900	777	897	787	877	844	764	830	797	807
80	897	777	897	784	867	850	768	837	820	814
90	898	780	900	790	867	854	770	847	824	820
100	898	787	900	794	877	857	770	847	824	824

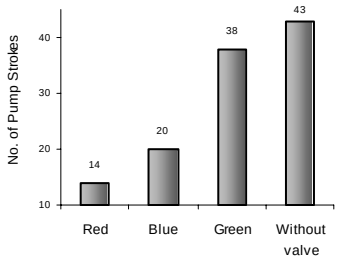
PP= Pump pressure; AFR1= Average flow rate for one nozzle; AFR2= Average flow rate for two nozzles; AFR3= Average flow rate for three nozzles; AFR4= Average flow rate for four nozzles

operated with four nozzles failed to maintain the rated flow rate of 800 mL/min and pressure of 45 psi specified for hollow cone nozzle under test so it may not be used with boom type sprayers.

The flow rate with green CFV for single nozzle was observed approximately 900 mL/min which decreased to a minimum value of 770 mL/min for four nozzles. Similarly, the operating pressure for single nozzle observed as 50 psi decreased to a minimum value of about 40 psi for four nozzles. The data given in Table IV for Green constant flow valve also show a change in the flow rate and nozzle pressure with increase in number of nozzles but the flow rate compares more closely with the rated flow rate of nozzle (800 mL/min) than other two valves. Therefore, Green valve is considered suitable for boom type sprayers.

Effect of CFVs on physical fatigue required for Knapsack sprayer. A knapsack sprayer mentioned in methods and materials section was used to estimate the amount of physical fatigue in terms of pump strokes. The data regarding the number of pump strokes required to spray a span of 200 feet with and without constant flow valves is presented in Fig. 2. The bars of Fig. 2 depict that the knapsack sprayer required 14 strokes with Red valve, 20 strokes with Blue valve, 38 strokes with Green valve and 43 strokes for without CFV. The data of physical effort clearly indicated that by installing Red valve 67%, with blue valve 53% and with green valve 12% less effort was required to spray when compared to a sprayer with no CFV. Finally, it may be concluded that the Red valve should be used with hand sprayers as it demanded less fatigue and maintained a uniform discharge close to rated nozzle discharge.

Fig. 2. Average number of pump strokes required to spray a span of 200 ft with a hand sprayer



CONCLUSIONS

The following conclusions may be drawn from the results discussed in preceding section.

1. The constant flow valves helped to maintain a more uniform flow rate and nozzle pressure which ensured

uniformity in droplet size and hence minimized the risk of pesticide loss and environmental pollution.

2. The Red constant flow valve was found to be more appropriate for hand sprayers commonly being used in Pakistan. It needed 67% less man effort than a sprayer without CFV. Furthermore, it maintained a uniform flow rate and pressure rated for hollow cone nozzle under test.

3. The Green constant flow valve was found to be more appropriate for boom type sprayer as it could maintain flow rate (800 mL/min) and 45 psi pressure rated for the nozzle under test.

4. The Green constant flow valve should not be used with hand sprayer as it operates at moderately higher pressure that may put the sprayer pump at risk.

5. The Blue constant flow valve may be used only with those hand sprayers which are capable to produce at least 45 psi pressure.

6. In general, the constant flow valves helped in reducing physical effort and associated operator's fatigue in case of knapsack sprayer.

RECOMMENDATIONS

Constant Flow Valves are handy and cost effective attachments. Knapsack sprayers with red valve performed much better by maintaining uniform pressure and nozzle discharge which controls the droplet size. The hand sprayer needed less man power when equipped with Red CFV. Similarly, boom type sprayer with Green valve was able to perform more closely to rated discharge and pressure conditions as compared to sprayer with no CFV. In the light of results obtained, it is recommended that the farmers and sprayers manufacturers should be encouraged to use this handy technology to save pesticides from being lost to soil, water and air environment.

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