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A Survey Study on Inspection of Field and Air-Assisted Orchard Sprayers in Use

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Abstract: In this work, some equipment and devices to be needed in Turkey for testing the sprayers were provided and standards (tst EN 13790-1 and tst EN 13790-2) in European Countries for mandatory or voluntary inspections of sprayers in use were applied to 30 field and 32 air-assisted orchard sprayers used in counties of Adana city of Turkey. It was determined many minor and critical defects on the sprayers by applying the standard tst EN 13790-1 and tst EN 13790-2 to the field and orchard sprayer in use. Especially, sprayers had problems such as no guards of power transmission, unusable level indicator of spray liquid tank, steadiness pointer of pressure gauge. In additional, some orchard sprayers had an ununiform spray distribution on the left and right side of spray outlet, and air guideline plate's problem. Mandatory inspection of sprayer in use also will provide better human and environment health care and decrease in using plant production products in Turkey.
Key words: Sprayer inspection, field and orchard sprayers, tst EN 13790-1, tst EN 13790-2

INTRODUCTION

There has been increasing pressure within the European Union and recently in Turkey to reduce the environmental and health impacts of pesticide use. Pesticides used in agricultural lands can cause contamination of water and residues in food. To reduce pesticide consumption and drift problems, pesticide application equipment must be well maintained, calibrated before each application and operated in the acceptable conditions. In July 2002 the European Commission (EC) issued a document entitled 'Towards a Thematic Strategy on the Sustainable Use of Pesticide' (Bals, 2004). While there are many aspects within the proposed strategy to minimize the hazards and risks to health and the environment from the use of pesticides, including banning, or severely restricting, aerial spraying, training of operators, increasing data collection (including records of use), etc a key area raised for discussion is the introduction of a system of regular technical inspection of application equipment which means the periodic inspection of sprayers in use in application in Member States. The document states that the EC consider 'Experience has shown mandatory systems to be more efficient than voluntary ones' (Bals, 2004). Mandatory inspection of sprayers currently in use can be a useful measure in order to achieve better control of plant production products (PPP's).

According to Ganzelmeier and Wehmann (2005), three most important reasons for such inspections are (a) to reduce the risk to the environment created by plant protection products, (b) to provide optimum plant protection using a minimum amount of PPP's, and (c) to ensure the safety of personnel. The first regular mandatory inspection of sprayers in Member States was made in July 1988 in Germany (Herbest and Ganzelmeier, 2002). Until now, two workshops were taken placed in Europe called as SPICE-1 and SPICE-2. SPICE-1 was taken place at the Federal Biological Research Centre for Agriculture and Forestry (BBA) in Braunschweig from 27 to 29 April 2004. SPISE-2 was taken placed in Straelen (Germany) from 10-12 April 2007. Present situation and standards were discussed in those workshops. According to data presented in SPISE-2, 20 countries of EC have mandatory inspection while only 4 members have voluntary inspections (Wehmann, 2007).

In spite of the differences between EU members, Mostly inspection of sprayers is carried out by officially

approved workshops. For example, in Germany besides the State Institute of Plant Protection, 4 state district administration authorities and 35 boards of agriculture are involved in the organization of sprayer inspection. The boards of agriculture are responsible for the execution as well as for checking the plant protection equipment. Differences between EU members are also important in matters such as the average inspection cost. The average inspection ranges from 200 € to 50 €. Where mandatory schemes are already established, sprayers usually have to be inspected every 2-3 years. Only few countries require other intervals (i.e. Italy, where sprayers have to be tested only every 5 years) and the average inspection frequency among member nations is 3 years (Gil, 2006).

In inspections of field and air-assisted sprayers in use for bush and tree crops sprayer, standard EN 13790-1(field sprayers) and EN 13790-2 (orchard sprayers) are applied in Europe. For applying these standards to sprayers in use, many devices and equipment are required such as test pressure gauges, flow meters, spray patternator, many fittings to all kind of connections and so on. The investment of any stations for sprayer inspections is relatively high such as 15.000-30.000 € (Tatrai, 2004). Turkey has not voluntary or mandatory sprayer inspections yet. But EN 13790-1 and 2 were confirmed in 2006 by Turkish Standards Institution as tst EN 13790-1 (Sprayers-Inspection of sprayers in use-Part 1: Field crop sprayers) and tst EN 13790-2 (Sprayers-Inspection of sprayers in use-Part 2: Air-assisted sprayers for bush and tree crops). The inspection procedure of sprayers and organization schemas of test stations haven't been organized yet in Turkey. There are 229 479 PTO driven sprayers and 73 015 Engine drive sprayers in use in Turkey (DİE, 2003).

The objectives of this study were to provide some basic test equipment for sprayer inspection to become a inspection station in progress and apply standard tst EN 13790-1 and 2 to sprayers in use to see the problems if the inspections are started in Turkey.

MATERIAL AND METHODS

The survey study was conducted in counties of Adana city of Turkey in 2006 and 2007. The numbers of inspected field and air-assisted orchard sprayers were 30 and 32, respectively. Some portable test devices were provided to inspect the sprayers in farm conditions. For measuring pump flow rate, an electromagnetic flow meter (Fig. 1; ARAG srl-Electromagnetic), for checking the pressure gauges, a few sensitive gauges (Fig. 2), for measuring nozzle flow rate, a tip tester flowmeter (Teejet Tip Tester) (Fig. 2, right picture), for determining the spray distribution, a portable patternator (Fig. 3) and many fittings were bought or produced to evaluate the sprayers compliance with EN 1390-1 and 2.

Fig. 1. Pump Flowmeter

Fig. 2. Pressure gauge and flowmeter

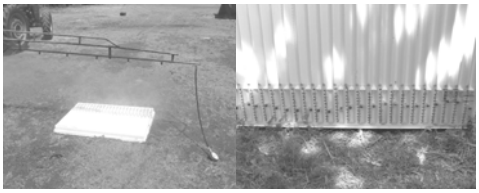

Fig 3. Portable paternator (Spraying system co.)

In order the check the field or air assisted orchard sprayer in use according to the related standards, a work sheet which is Annex B attached to EN 13790-1 and 2 was used. All requirements and methods of verification in inspection were done according to the tse EN 13790-1 and 2. Contents of tse EN 13790-1 and 2 were summarized the following subheadings and refereed the related section numbering if needed.

Power transmission parts and blower

For field and orchard sprayers, the power take-off drive shaft guard and guard of the power input connection shall be fitted and good condition. Methods of verification: inspection and function test.

For air assisted orchard sprayers, the blower (fan, casing, air deflectors) shall be present, in good condition and manner. Inspection of bower shall be according to 4.1.3.

Pump

The pump capacity shall be at least 90% of its original nominal flow, given by the manufacturer of the sprayer. Method of verification: measurement according to 5.2.1.a); or 4.2.1 b). There shall be no visible pulsations caused by the pump. Method of verification: inspection and function test. When there is a pressure safety valve on the pressure side of the pump, this valve shall work reliably. Method of verification: inspection and function test.

Agitation

A clearly visible recirculation shall be achieved when spraying at the nominal PTO speed, with the tank filled to the half of its nominal capacity. Method of verification: inspection.

Spray liquid tank

There shall be no leakages from the tank or from the filling hole when the cover is closed. There shall be a strainer in good condition in the filing and a clearly readable liquid level indicator on the tank.

Measuring, controls and regulation systems

All devices for measuring, switching on and off and adjusting pressure and/or flowrate shall work reliably and there shall be no leakages. The scale of the pressure gauge shall be clearly readable and suitable for the working pressure range used. In additional, switching on and off of all nozzles shall be possible simultaneously for air-assisted orchard sprayers.

Pipes and hoses

There shall be no leakages from pipes or hoses when tested up to a maximum obtainable pressure for the system.

Filtering

There shall be at least one filter on the pressure side of the pump and in case of positive displacement pumps also one filter on the suction side.

Spray boom for field sprayers

The boom shall be stable in all directions, i.e. not loose in any joints and not be bent. The boom shall be securely lockable in the transport position.

Nozzles

For field sprayer, all nozzles shall be identical all along the boom. For orchard sprayers, the nozzle equipment (e.g. nozzle types, sizes) shall be symmetrical on the left and right hand sides. It shall be possible to switch off each nozzle separately. For field and orchard sprayers, after being switched off, the nozzles shall not drip after 5 s later.

For orchard sprayers, the output of each nozzle with the same marking shall not deviate more than 15 % from the nominal output or 10 % from the mean output of all nozzles within the same identification (Fig. 4 and 5).

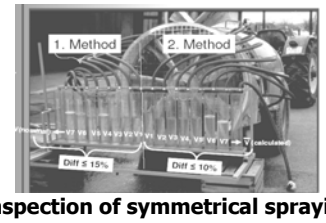

Fig. 4. Inspection of symmetrical spraying for air assisted orchard sprayers (from Ganzelmeier, 2007)

Fig. 5. Inspection and function tests of orchard sprayers

For symmetrical spraying, the difference between the left and right hand sides mean output shall be a maximum of 10 %.

Transverse distribution for field and distribution for air-assisted orchard sprayer

For the transverse distribution of field sprayers, the requirements and test methods of 4.10.1 or 4.10.2 shall apply. A patternator shall be used and coefficient of variation shall not exceed 10%, and the amount of liquid within each groove shall evaluate according to 4.10.1 b). The pressure differences at each section inlet shall be a maximum of 15%.

Blowers

The blower shall rotate at the speed specified by the manufacturer and can be switched off separately from other driven parts of the machine, the clutch shall work reliably. Air guide plates shall function properly.

RESEARCH RESULTS

Power transmission parts

Many of the inspected filed and orchard sprayers did not have a PTO shaft guard (Fig. 6). Eighty- six percent of filed sprayers and seventy-two percent of

orchard sprayers did not have any guards on their PTO shafts. And PTO shafts of 28 % of orchard sprayers had problems regarding the universal joints and locking systems.

Fig. 6. Inspection the PTO shaft guard

Pump

Inspected sprayers mostly have diaphragm types of pumps. Stickers on the pumps actually did not have a full inform of pump working characteristics. For example, a lot of stickers were just showing the maximum pressure and pump revolution. So it was very difficult to compare the measured pump flow rate with its nominal flow rate. The other results for pumps are given in Table 1 and 2.

Table 1. Pump defects of field sprayers

Requirement	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers*
	No	Minor	critical	(%)
-Pulsations	27	3	0	10
-Pressure safety valve	13	2	15	53
-Leakages	26	3	1	13

*: Number of sprayers with critical and minor defects were divided by numbers of total inspected sprayers.

Table 2. Pump defects of orchard sprayers

Requirement	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers
	No	Minor	Critical	(%)
-Pulsations	25	4	3	21
-Pressure safety valve	27	0	5	15
-Leakages	27	3	2	15

As shown in Table 1, most field sprayers had the pressure safety valve defects while the pulsation was the biggest problem in orchard sprayer (Table 2).

Agitation

In the survey, 60 % of inspected filed sprayers had hydraulic agitation defects while the others had mechanic plus hydraulic agitation. The situation for orchard sprayers was 40 % hydraulic agitation, 50 % mechanic plus hydraulic agitation and 4 % only mechanic agitation. A clearly visible recirculation was achieved when spraying at the nominal PTO speed in tanks of field and orchard sprayers.

Spray liquid tank

Seventy-three percent of field sprayers had 1000 l tank capacity while the others were smaller than this capacity. 80 % of orchard sprayers had 1000 l tank capacity. The results of inspection for tanks are given in Table 3 and 4.

Table 3. Liquid tank defects of inspected field sprayers

Requirement	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers
	No	Minor	Critical	(%)
-Leakages	25	3	2	16
-Strainer	30	0	0	0
-Pressure compensations	17	5	8	43
-Level indicator	10	6	14	66
-Emptying	24	4	2	20
-By pass	27	2	1	10
-Cleaning device	1	0	0	0

Table 4. Liquid tank inspections of orchard sprayers

Requirement	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers
	No	Minor	critical	(%)
-Leakages	29	2	1	9
-Strainer	26	4	2	19
-Pressure compensations	22	10	8	56
-Level indicator	17	9	6	47
-Emptying	24	6	0	19
-By pass	26	5	1	19
-Cleaning device	0	0	0	0

As shown in Table 3, the biggest defect ratio in inspected field sprayers was liquid level indicator while the pressure compensation system in the tank was the biggest defects in orchard sprayers (Table 4).

Measuring, controls and regulation systems

The inspection results of measuring systems of field and orchard sprayers are given in table 5 and 6.

Table 5. Inspection results of measuring and control systems of field sprayers

Requirement	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers
	No	Minor	Critical	(%)
-Function	25	0	5	16
-Leakages	26	4	0	13
-Pressure gauge	27	0	3	10
-Marking	23	4	3	23
-Diameter	28	0	2	6
-Accuracy	23	0	7	23
-Steadiness of pointer	15	10	5	50
-Operation controls	20	7	3	33

As shown in Table 5 and 6, the maximum defects in measuring and control systems of sprayers inspected were in the steadiness of pointer of pressure gauges in both field (50 %) and orchard sprayers (47 %).

Table 6. The check results of measuring and control systems of orchard sprayers

Requirement	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers
	No	Minor	Critical	(%)
-Function	26	5	1	19
-Leakages	30	1	1	6
-Pressure gauge	23	7	2	28
-Marking	25	4	3	22
-Diameter	30	0	2	6
-Accuracy	29	0	3	9
-Steadiness of pointer	17	11	4	47
-Operation controls	27	2	3	16

Pipes and hoses

Some inspected filed sprayers had leakages and bending/abrasion defects. But the ratio of these sprayers was 9%. The rate of sprayers having hose or pipe defects was 18 % in orchard sprayers.

Filtering

Twenty-three percent of inspected field sprayers had filtering defects. The rate of sprayers having these defects was 25 % in orchard sprayers.

Spray boom

Defects observed in field sprayer inspections are given in Table 7**.**

Table 7. Spray boom defects

Requirement	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers
	No	Minor	Critical	(%)
-Stability	11	9	10	63
-Symmetry	11	9	10	63
-Safely lockable	25	0	5	16
-Nozzle spacing	24	4	2	20
-Nozzle height	21	8	1	30
-Sprayer contamination	18	6	6	40
-Prevention of nozzle damage	0	0	0	0
-Boom section control	28	1	1	6
-Height adjustment	21	3	6	30
-Damping	4	24	2	86
-Slope compensation	19	1	10	36
-Pressure variation at section inlets (<10%)	27	0	3	10

As shown in Table 7, a considerable rate of field sprayers had damping, stability and symmetry defects. Also rate of sprayers having contamination defect due to nozzle dripping was fairly high.

Nozzles

For field and orchard sprayers, there were no data providing by owners of sprayers or nozzle manufacturers to compare measured flow rate with nominal rate. When the nozzles on the boom were checked, mostly booms had been equipped same type of nozzles except only two field sprayers. Twenty-eight of orchard sprayers have symmetry defect problem. About 70 % of inspected field and orchard sprayers did not have any diaphragm check valves on their bodies.

Distribution

Transverse distribution of filed sprayers is given in Table 8.

Table 8. Spray distribution of field sprayers.

Distribution parameters	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers
	No	Minor	Critical	(%)
-Coefficient of variation (≤10%)	15	3	12	50
-Max.deviation from mean(≤20%)	17	4	9	43
-Pressure drop (≤10%)	22	3	5	26

The main defects regarding spray distribution in inspected field sprayers were in the variation of spray distribution on the patternator (Table 8). Fifty percent of field sprayers had this defect.

The spray distributions from the spray units of orchard sprayers are given in Table 9.

Table 9. Spray distribution of orchard sprayers.

Distribution parameters	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers
	No	Minor	Critical	(%)
-Uniformity of spray jet	23	3	6	28
-Mean output left/right side (≤10%)	21	8	3	34
-Pressure differences at section inlet (≤15%)	25	5	2	22

As shown in Table 9, the mean flow rate defects due to left-right side deviations in flow were bigger then the other defects in inspected orchard sprayers.

Blower

The blower situations of inspected orchard sprayers are given in Table 10. The main defects in orchard sprayers were in position of the air guide plates'. Some sprayers did not have any air plates or plates for directing the air to have a better air jet distribution.

Table 10. Blower defects of orchard sprayers.

Requirement	Numbers of inspected sprayers (Defect)			Ratio of defect sprayers (%)
	No	Minor	critical	
-Rotational speed	30	2	0	6
-Switching off	29	2	1	9
-Guide plates	19	8	5	41
-Dripping	31	1	0	3

DISCUSSION and CONCLUSIONS

The equipment and devices are very important to inspect the sprayers in farm conditions. Especially, voluntary inspections such being done in this survey require more preparations to accomplish the all measuring or visual checks in a short time. A truck equipped with all necessary devices can help the inspection team.

This survey study has shown that many of sprayers must be repaired to provide the requirements in the standard if the tst EN 13790-1 and 2 are applied to sprayer in use. However, Langenakens and Pieters (1999) illustrated that a sprayer is only rejected when the defects have a major influence on the final spraying results while for less important defects, a demand for repair is done to the owner of sprayer inspected. Many field and orchard sprayers inspected in this survey did not have any guards on PTO shafts. Operating the PTO shafts without guards may have any accident unexpected. Considering minor and critical defects on liquid tanks, many of field and orchard sprayers had liquid level indicator problems. Sixty-six percent of field and forty-seven percent of orchard sprayers had tank level indicator defects. It wasn't possible to compare the nominal flowrate of pumps with measured flowrate at illustrated maximum pressure on pumps' sticker. In spite of many defects in measuring and control systems of inspected sprayers, about fifty percent of field and orchard sprayer had steadiness of pointer defects in pressure gauges. Nearly 70 % of inspected field and orchard sprayers did not have antidrip nozzle bodies. Also, there was no nozzle information to compare nozzle flowrate with their nominal flowrate. So, owners of sprayers should have the nozzle operating parameters to check those according standards. To evaluate the spray distribution, a portable patternator can be used, but it should have graded cylinders on it at least. Guide plates defects of blowers on orchard sprayers were the biggest defects within the other blower defects. As shown in tables given in section of results, there are many defects on sprayers in use. If the standards tst EN 137901-2 are acted in Turkey, many sprayers in use will be needed to repair. Thus, amount of spray loses and numbers of misapplication due to defect on sprayers can be reduced. According to Gil (2006), a reduction in use of PPP's is estimated to range from 5 to 10% if regular controls being done. Especially, mandatory inspections of sprayers in use also will provide better human and environment health care in Turkey.

REFERENCES

Bals, T.E. 2004. European Regulation Of Application Equipment. ASABE meeting paper No: 041087.Ontario, Canada

DİE. 2003. Tarım İstatistikleri Özeti.T.C. Başbakanlık Devlet İstatistik Enstitüsü. Ankara.

Ganzelmeier H., H.J. Wehmann, 2005. First European Workshop On Standardized Procedure For Inspection Of Sprayers In Europe (SPISE). Bulletin OEPP/EPPO Bulletin 35, 245-248.

Ganzelmeier, H. 2007. European Standard EN 13790

Part 2: Air-Assisted Sprayers For Bush And Tree Crops The Basis For Sprayer İnspection İn Europe. Second European Workshop On Standardized Procedure For Inspection Of Sprayers İn Europe-SPISE 2. 10 to 12 April 2007 Straelen.

Gil, E. 2006. Inspection Of Sprayers In Use: A European Sustainable Strategy To Reduce Pesticide Use In Fruit Crops. ASABE Annual International Meeting. Paper NO. 061130. Portland Oregon.

Herbest, A., H. Ganzelmeier, 2002. International Standards And Their Impact On Pesticide Application. Aspects of Applied Biology 66. International advances in pesticide application.

Langenakens, J., M. Pieters, 1999. Organization And Results Of The Compulsory Inspection Of Sprayers In Belgium. 7th International Congress on Agricultural Mechanization and Energy.50-53. Adana, Turkey.

Tatrai, G. F. 2004. EU-Conform Tests And Compulsory Regular Inspection Of Plant-Protection Machines In Hungary. Hungarian Institute of Agricultural Engineering. Gödöllö,Tessedik, Hungary.

Wehmann, H.J. 2007. Actual Survey About Inspection Of Sprayers In The Countries Of Europe.Standardized Procedure For The Inspection Of Sprayers In Europe. SPICE 2 10-12 April 2007, Straelen. Germany