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Full Length Research Paper

Determination of accuracy level of agricultural spraying application in Sanliurfa/ Turkey

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When calibration, spraying height, applied pressure, volume rate, nozzle type and application time of equipment used in pesticide applications are incorrect, this causes the amount of agricultural pesticide applied per unit area to be more or less needed. A survey study was carried out on farmers in order to determine whether or not they adjust application pressure of pesticide equipment, nozzle type, volume rate, spraying height and calibration of spraying equipment needed for pesticide application to have values, and also whether or not they carry out agricultural pesticide application in accurate weather conditions such as wind speed, air temperature, relative humidity, temperature and application time. This research was conducted in 2008 by randomly determining 110 agricultural organizations located in villages in the center of Sanliurfa/Turkey and its districts. Survey study was carried out by taking data from pesticide applications processes made on products such as cotton, wheat, barley, lentils and corn which have been intensely produced in the region. It was determined that in general, farmers operated field sprayer at very high pressures in agricultural pesticide application and they did not adjust travel speed of boom sprayer based on the calibration of pesticide application equipment. Moreover, based on data obtained from survey studies, application operators and farmers did not know values of wind speed, temperature and relative humidity required for agricultural pesticide applications.

Key words: Pesticide spraying applications, survey, accuracy level, spraying parameters.

INTRODUCTION

Using of pesticide has increased for the purpose of obtaining more products with higher quality from a unit area. Pesticides cause significant damages to the environment in nature when used unconsciously. During applications, pesticide particles are transferred into air, soil, underground water by means of rain from soil and therefore they are transferred into water ecosystem and cause environmental pollution by disturbing natural balance (Akkaya and Akkaya, 1995). Therefore, if appropriate equipment is not used in pesticide application, pesticides can cause serious human health and environment problems. (Bozdogan and Yarpuz-Bozdogan, 2008) Usage of pesticides in agriculture in a manner that minimizes damage to the environment plays a fundamental role in economical development. Especially, apart from benefit of applications made with pesticides in agriculture production, it may be harmful to the environment when made without experience or control (Celen, 2001). In agricultural food production, positive results can be obtained by using appropriate pesticides through the application of appropriate methods (Yarpuz-Bozdogan et al., 2011).

In Sanliurfa Province (Turkey) where a low number of sprayer is owned per tractor, using current sprayers under favorable conditions directly affects success of agricultural protection against diseases and weeds in vegetative production. For that reason, during application great importance should be given to sprayers which are used in pesticide application in our region and in the country. When equipment used for pesticide application, calibration of used pesticide equipment, spraying height, applied pressure, volume rate, nozzle type and application time of equipment used in pesticide applications are incorrect, the amount of agricultural pesticide applied

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per unit area is more or less needed. As a result, it causes decrease in pesticide application efficiency, increase in pesticide costs and leads to environmental pollution.

In a study made on the condition of sprayers in agricultural organizations in Tekirdag Province (Turkey), blockages were determined in 28% of pesticide application nozzles and only 11% of agricultural organizations continuously checked nozzles and replaced when irregularity was observed (Demir and Celen, 2005). It was determined that within Van Province (Turkey), the most widely used nozzle type was hollow cone nozzles and no one of the pesticide operators received training on pesticide application within the boundaries of the province (Bolat et al., 2003). In Turkey, it has been widely used as hollow cone nozzles with swirl plate (Dursun et al., 2005) and flat fan nozzles with 110° fan (Aksoy and Bayat, 1996; Yarpuz-Bozdogan et al., 2011).

Factors having significant role in pesticide drift can be given as follows: weather conditions at the time of application such as wind speed and direction, air temperature, relative humidity, atmospheric stability and reverse air flow, droplet diameter and spectrum; characteristics of pesticide formulation such as evaporation and viscosity, application height, knowledge and experience of operator. In pesticide applications, pesticide deposition on off-target can be reduced by using appropriate nozzles (Yarpuz-Bozdogan and Bozdogan, 2009). Since farmers have limited knowledge on sprayers and their application, excess amount of pesticide has been used in pesticide applications. Also, they decide based on their own experience while deciding on method of pesticide applications and they have no sufficient knowledge on selection of method and sprayer (Pinar et al., 2001). In pesticide application, sprayers were operated at high pressures. Farmers and operators, who carry out the application, believe that the most efficient pesticide application can be achieved at higher volume rate and pressure (Saglam and Saglam, 2000).

Unfortunately in many countries, the pesticide application practised on field level often reflected technical standards of 40 years ago, resulting in a waste of pesticides and unnecessary environmental contamination (Friedrich, 1996). In previous studies, it was undetermined whether or not farmers adjust application pressure of pesticide equipment, nozzle type, volume rate, spraying height and calibration of spraying equipment that pesticide applications need to have values, and whether or not they carry out pesticide applicaiton in accurate weather conditions such as wind speed, air temperature, relative humidity, temperature and application time. In this study, the level of knowledge of farmers or application operators with respect to pesticide application correctly was determined. Also, mechanization level of region was determined with respect to pesticide application within the scope of this study.

MATERIALS and METHODS

In this study, a survey was carried out in 2008 on 110 farmers who were selected randomly from central Sanliurfa and its districts in order to determine calibration adjustment, spraying height and weather conditions at the time of spray application such as wind speed, air temperature, relative humidity and application time during pesticide application. In this study, it was determined the level of knowledge of farmers or application operators with respect to pesticide application and whether they are applied correctly. In this study, data were gathered by interview with farmers or application operators in survey studies. Also, necessary data were taken by making observation during pesticide application with sprayer from 25 of the survey made in this study.

Various scenarios were prepared in order to determine whether farmers made applications properly during pesticide application. These were: Type of nozzle, material of production of spraying nozzle and time of usage, application pressure of sprayer, traveling speed of sprayers and calibration adjustment of crop sprayer, height of boom, distance between two spraying nozzles and meteorological conditions at the time of application such as wind speed, relative humidity, air temperature, spraying time. Also, mechanization level of Sanliurfa, Southeastern Anatolia Project (GAP) and Turkey was determined with respect to pesticide application mechanization.

Nozzle type and application pressure scenario

In this study, the type of nozzles used by farmers according to the type of agricultural application was determined at the end of the survey. Accordingly, operating pressure of sprayer considering type of nozzle in pesticide application in farm products should be between the following values: Flat fan nozzles, herbicides: 1.5 to 3 bar, fungicides and insecticides: 2 to 5 bar; hollow cone nozzles, fungicides and insecticides: 5 to 8 bar. Flat fan nozzles are favorable mostly for herbicide applications in conditions where pesticide penetration is not required and they can also be used in some pesticide applications. Fan angles in these nozzles change between 65 to 110° and commonly 80° nozzles are used . Spraying height changes according to the fan angle in conventional nozzles which were placed in 50 cm distances on boom and minimum of 50% overlap is required for a uniform cover in surface distribution. Optimum operating pressure for those types of nozzles is informed as 2 to 3 bar (Srivastava et al., 1993; Johnson, 2011).

It is recommended to use hollow cone nozzles with swirl plate where surface cover is important in leaf pesticide. These types of nozzles are suitable for herbicide, insecticide and fungicide applications having contact effect (Dursun et al., 2000). Another type of nozzle is cone nozzle with swirl plate. Cone angle is 130° in these nozzles, which is used for systemic herbicide applications in mostly surface applications and it is connected to spraying boom with 45° (Srivastava et al., 1993).

In this study, it was also asked the use time of the spraying nozzle and type of material within the scope of survey. According to the measurements made before and after abrasion, increases of 10.5, 10.9 and 1.47% were observed respectively in outputs of cone nozzles made from plastic, stainless steel and ceramic material (Ergul and Dursun, 2004). According to this, it is required to replace spraying nozzles frequently according to the material type made.

Travel speed and calibration adjustment of crop sprayer scenario

Operators and farmers were asked whether they made calibration adjustment of the sprayer and how to adjust sprayer travel speed.

The most important point here is to determine travel speed of boom sprayer according to the calibration of the sprayer. For instance, travel speed of sprayer and calibration of a sprayer can be determined in this way. Firstly, in order to determine application volume rate of sprayer, it must be required to measure nozzle output through checking sprayer adjustments.

After that, pesticide tool filled with water at a certain level is operated at 5 to 10 m distance from the starting point marked and while it is moving with normal pesticide application speed, the second pointer is noted from the beginning; and at the end of the mark, the time of covering 60 m passage is determined. Here, if tractor passes 120 m passage within 60 s, speed of tractor per min is 120 m and its speed per h is 7.2. After that, in order to find pesticide application volume:

$$N = (600.Q) / (B.V)$$

Equation is used (Matthews, 1992).

Where; N: Pesticide application volume (L/ha), Q: Nozzle flow rate (L/min), B: Swath width (m), V: travel speed of field sprayer (km/h).

After that, area to be disinfected and dose of pesticide to be applied with a full tank must be found. The important point here is to adjust travel speed of boom sprayer according to the calibration of sprayer. Lower value from the selected speed causes application of more pesticide and this increases input costs of that organization. High travel, boom travel of sprayer causes lower amount of pesticide in unit area and agricultural pesticide has no sufficient effect against diseases or weeds.

Height of spraying boom of sprayer and spraying nozzle distance scenario

In this scenario, height of boom and distance between two nozzles was taken based on pesticide application on products of farmers or current production pattern. It is required that farmers and application operators determine pesticide height according to the catalog value of spraying nozzle, which is used in pesticide applications. Additionally, when height of spraying boom increases, generally wind speed increases. Thus, distance to the target of drop increases with increase in nozzle height and in this way they are subject to drift of wind for a longer time. Also, while sprayer boom height is decreased drift deposition is lower. When boom height in combination with using of air-assistance was decreased sedimenting and airborne drift was reduced significantly compared to the conventional spraying (TeeJet XR 110 04 nozzles, 300 $L.ha^{-1}$, no air-support, 0.50 m boom height) (De Jong et al., 2000).

Also, lowering the boom height from 0.50 to 0.30 m in combination with reducing nozzle spacing from 0.50 to 0.25 m and using smaller nozzles sizes still reduced drift significantly (Stallinga et al., 2004).

Correct boom height for each nozzle type is determined by nozzle spacing and spray angle. Wide-angle nozzles can be placed closer to the ground than narrow-angle nozzles and wide-angle nozzles produce smaller droplets (Nuyttens, 2007). Modification of nozzle number, nozzle type and orientation is usually required to maintain an even spray pattern when lowering the spray boom (Nuyttens, 2007). Distance between two spraying nozzle is generally required to be adjusted as 50 cm. If distance of spraying nozzles is not considered, then sufficient covering margin cannot be provided. Covering of liquid sprayed from nozzles in surface pesticide application is required for a normal distribution. In case of a shorter distance between spraying nozzle, a sufficient covering margin and pesticide application cannot be achieved. Covering is not made in band applications in pesticide applications.

Scenario regarding meteorological conditions such as wind speed and direction, relative humidity, air temperature during application

Low relative humidity and high temperature conditions cause rapid evaporation of pesticide drops and more quantities of pesticide drift. For that reason, in conditions when temperature is higher than 30°C and relative humidity is higher than 80%, pesticide application should not be carried out. Also, wind speed from meteorological conditions is one of the most important factors affecting pesticide drift. When wind speed increases, then amount of pesticide carried outside the target area and movement distance of these pesticides increase. When a drop falls within air, then surface molecules of water evaporate. This evaporation decreases size and weight of drops and causes drift further from the application region. When wind speed exceeds 10 km/h, pesticide applications should not be carried out (Piche et al., 2000).

Under normal weather conditions, air tends to rise and mix with the air above. Droplets disperse and usually do not cause problems. Pesticide particles sprayed under these weather conditions are distributed as desired and cause no problem (Anonymous, 2008). For these reasons, pesticide application should be started after removal of dew on the plant in the morning and after a certain time in the afternoon. Also, in weather conditions when there is no wind, no pesticide application should be carried out. In these weather conditions, small particle size drops suspend in the air, even though there is no wind, and small particle size drops are transferred to very long distance which is undesirable. In calm weather conditions, air layer on the earth surface becomes cold and the layer on that remains hot as can be observed at night. In this way, temperature change is reversed and temperature increases until a certain level. This weather condition is called temperature inversion. Since earth surface is denser in this temperature layer, air layer cannot be moved up. When pesticide is applied under these weather conditions, since small particles are suspended in the air, they could move to unwanted locations (Anonymous, 2008).

RESULTS AND DISCUSSION

Existence of sprayer pesticide equipment which was widely used in our country and rates of sprayers per one tractor were compared in Turkey, (Southern-East Project) GAP and Sanliurfa regions in Table 1. According to Table 1, it can be seen that the rate of sprayer /tractor in Turkey was higher than the rate of GAP region and Sanliurfa and also, rate of sprayers per tractor driven by power-take off in Sanliurfa Province was higher than GAP region. Increased rates that occurred in Turkey, GAP Region and Sanliurfa are given in Table 2 between 1995 and 2008. As seen in Table 2, while number of sprayer driven by power take-off is 68% in Turkey between 1995 and 2008, increased rates in GAP and Sanliurfa were 108 and 124% respectively. The reason of higher number of sprayers in GAP and Sanliurfa regions was the increasing income level that depends on starting agricultural irrigation at the GAP region.

Within the scope of this survey, apart from sprayers and tractors, other machinery that found in farms were also determined. Accordingly, it was determined in agricultural organizations, 102 tractors, 72 sprayers driven by power take-off, 138 ploughs, 98 cultivators, 105

Table 1. Number of sprayers in Turkey, GAP Region and Sanliurfa and rate of sprayers per tractor.

Years	Sprayer driven from power take off (numbers)			Sprayer /Tractor		
	Turkey	GAP Provinces	Şanlıurfa	Turkey	GAP Provinces	Sanlıurfa
1994	154 159	3 433	1 067	0.203	0.095	0.145
1995	154 659	3 798	1 156	0.195	0.102	0.146
1996	165940	4 330	1 208	0.205	0.109	0.130
1997	187 426	4 835	1 709	0.214	0.112	0.153
1998	202 101	5 286	1 942	0.224	0.115	0.161
1999	210 300	5 955	2 069	0.227	0.129	0.169
2000	216 525	6 004	2 022	0.229	0.126	0.162
2003	229 497	6 569	2 205	0.230	0.138	0.173
2007	255 582	7 742	2 545	0.241	0.149	0.191
2008	259 475	7 892	2 588	0.242	0.151	0.194

Table 2. Changes in numbers of sprayers between 1995 to 2008 in Turkey, Sanliurfa and GAP Region.

Region	Numbers of sprayer from power take off		Increase rate(%)	Numbers of sprayer/Tractor		Increase rate(%)
	1995	2008		1995	2008	
Türkiye	154 659	259 475	68	0.195	0.242	24
GAP	3 798	7 892	108	0.102	0.151	48
S.urfa	1 156	2 588	124	0.146	0.194	33

Table 3. The presence of machinery per tractor in organizations where survey was carried out.

Name of implement and machine	Quantity (pieces)	Machine/ Tractor
Tractor	102	1.000
Sprayer from power take off	72	0.705
Plough	138	1.352
Cultivator	98	0.960
Harrow	105	1.029
Cotton planting machine	35	0.343
Cereals planting machine	78	0.761
Pneumatic planting machine	25	0.245
Manure distributor	61	0.598
Hoe machine	44	0.431
Trailer	96	0.941

harrows, 35 cotton planters, 78 grain planters, 25 pneumatic planting machines, 61 manure distributors, 44 hoeing machines and 96 trailers (Table 3). Sprayers driven by power take-off have been identified in 72 of 110 agricultural organizations inspected within the scope of the survey. Rate of sprayers driven by power take-off/tractor was 0.705 in studies carried out in Sanliurfa Province and villages within the boundaries of central district. Organizations having no sprayer supply for their needs from their neighbors or by means of renting.

Different marking and size sprayers were observed in agricultural organizations where survey was made. Lengths of boom, tank capacities and models of sprayer determined at visited organizations were given in Figures 1, 2 and 3. Accordingly, the most chosen tank capacity was 400 L with 56% and boom width was 12 m with 53% rate in agricultural organizations. Ages of sprayer in surveyed agricultural organizations were 22% of them

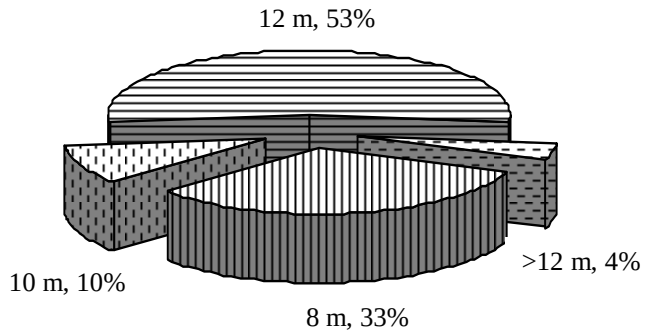


Figure 1. Length of boom.

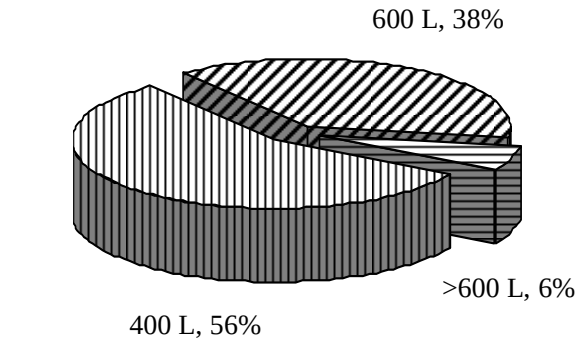


Figure 2. Sprayer tank capacity.

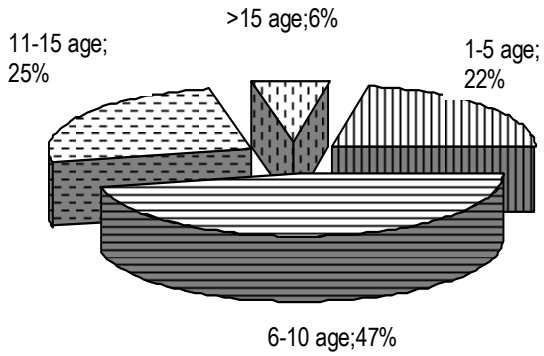


Figure 3. Age of sprayers.

between 1 to 5 years; 47% of them between 6 to 10 years; 25% of them between 11 to 15 years; 6% of them between 16 or above and finally 3% of them between 21 or above (Figure 3). From here, it can be seen that most of the sprayers (69%) are around 10 years or lower.

Nozzle type and application pressure scenario

According to the survey study results within Sanliurfa, commonly used nozzle type among farm sprayers was hollow cone nozzles. In pesticide application, among 110 agricultural organizations, 90 (81.8%) of them use hollow cone nozzle on boom and 20 (18.2%) of them use flat fan spraying nozzle on boom. 90% of farmers make pesticide application against weeds and diseases with one spraying nozzle and in general they used generally hollow cone spraying nozzles. Weed pesticide application was not needed by 10 % of farmers and they indicated that they used cone nozzles against weeds and diseases.

According to that, different types of equipment must be used in spraying chemical substances on target. Any sprayer equipped with single type nozzle is used on every pesticide application without taking into account requirements. Yet, location, size and behavior of diseases and weeds on plants are very important when choosing pesticide application method. Depending on the purpose of application in pesticide applications, it may require different types of spraying nozzles (Yarpuz-Bozdogan 2005). Droplets sprayed by cone and flat fan nozzles are retained firstly by upper leaves of plant and nearly no pesticide reaches to the leaves of plant near soil and bottom surfaces of leaves. Also, when pesticides were applied with hollow cone and flat fan nozzles, penetration of pesticide was low (Zhu et al., 2004). In organizations where survey was carried out, it was observed that farmers did not use any spraying nozzle such as Drift Guard, Air induction and Turbo Flood which lower pesticide drift or any air assisted boom sprayer which increases pesticide efficiency in pesticide applications. Drift Guard, Air induction and Turbo Flood nozzles can produce larger droplets in the same output and operating pressure with respect to standard type flat fan nozzles. In these type nozzles, number of droplets smaller than 200 µm can be lowered in the rate of 50 to 80%.

In this way, droplets with lower tendency to drift can be seen with respect to standard flat fan nozzles in the same size. In these nozzles, there is a front orifice which can be observed and while liquid passes from this front orifice, its speed is lowered and it exits as larger droplets from the main exit orifice (Ozkan, 1998). In pesticide application, farmers or application operators used a sprayer under a very high application pressure. Many farmers and application operators indicated that high application pressure penetrated better pesticide between plant leaves and lower sections of plant and more pesticide which could be supplied to the target. According to 110 survey study made, only 26 (23.6%) farmers made application lower than 10 bars. The remaining 29 farmers that carried out pesticide application with 10 bar, 41 of them had 12 bars and 15 of them, 15 bars. 8 farmers indicated that they did not know due to the faulty manometer during the survey study. According to these studies, 69.1% of farmers made application of 10 bars and above in pesticide applications. Higher pressures generate many more small droplets less than 150 microns. Extended range flat fan nozzles are designed to

produce a uniform spray pattern down to 15 to 20 psi and at this pressure, fine spray drops are reduced considerably. It is recommended not to use operating pressures that exceed 35 to 40 psi or where significant fine drops are produced (Wolf, 2000).

In this study, farmers or application operators have used spraying nozzles for a very long time in pesticide application and they did not know the material used in the production of spraying nozzle or plate. 75 (68%) farmers or application operators determined usage periods of spraying nozzles based on experience and there is no clear knowledge about usage period of spraying nozzle of 20 farmers. 15 (14%) farmers replaced spraying nozzles once in 3 to 4 years and only 11 farmers could be able to indicate material that spraying nozzle produced and again they said that they determined usage periods of spraying nozzles based on experience. When spraying nozzle is damaged, distribution of pesticide is disturbed with damage to the droplet spectrum, biological efficiency is adversely affected; and as a result, more pesticide is used and causes environmental pollution (Saglam and Deligönül, 1997; Saglam, 1998). Also, non-calibrated and insensible usage in sprayer and spraying nozzles causes excess amount of pesticide (Saglam, 1998).

Travel speed and calibration adjustment of crop sprayer scenario

Farmers indicated that they made calibration based on their experience or their previous pesticide applications. Most of the farmers did not adjust volume rate depending on calibration. It was clarified that 65 (60%) farmers or application operator conducted survey said that they adjusted calibration of crop sprayer and volume rate based on their experience and prospectus of pesticide. Agricultural pesticide applications have been made by being based on their experience and 22 of the farmers said that they received assistance from employees of company where pesticides were purchased and they did not require any calibration on crop sprayer. Although 23 farmers said that they made calibration, when they were asked how to adjust sprayer travel speed, they clarified that they adjusted travel speed of sprayers based on their experiences.

Height of spraying boom of crop sprayer and spraying nozzles distance scenario

Farmers or application operators did not use any measurement equipment while measuring distance between pesticide application height and distance between two spraying nozzles in pesticide application. In survey studies made in the field, even though farmers indicated that they adjusted spraying height 90 cm above from the ground, it came out that they applied pesticide around 110 to 120 cm as a result of measurements made. This was caused most probably from making adjustment of spraying by farmers based on their experiences or visual adjustment. In the production of wheat, barley and cotton, pesticide was applied between 100 to 110 cm. Especially in survey study, agricultural pesticide application was made by crushing plant and it was observed that no high frame crop sprayer was used in sunn pest and weed application

In interview made with farmers and survey studies in the field, 95% of farmers said that they adjusted sprayer boom height according to the development of plant and their experiences. Also, farmers did not use nozzle catalogue values while they adjusted sprayer boom height in pesticide application. Spraying drift can be reduced by mounting the spray boom closer to the sprayed surface without sacrificing the uniformity of the spray pattern, as long as nozzle discharge angle is increased. That is why wind speed increases with height. The correct spray height for each nozzle is determined by the nozzle spacing and the spray angle. Wide-angle nozzles also produce smaller droplets, offsetting some of the advantage of a lower boom height (Wolf, 2000). Distance between two spraying nozzle was adjusted as 50 cm by 90% of farmers. 10% of farmers adjusted distance between two spraying nozzle according to the distance of plants.

Meteorological conditions such as wind speed, relative humidity, air temperature and application time scenario

During pesticide application, farmers did not use any device for measuring meteorological data. Some farmers monitored meteorological conditions from weather forecast in television a couple of days before starting pesticide application. Some farmers indicated that when they were forced to, they made pesticide application with higher pressures and lower speeds in windy weathers. One of the most significant problems among meteorological conditions was correct starting time for pesticide application, but incorrect completion time of pesticide application. Farmer or application operator starts pesticide application in the early morning hours and continues pesticide application until midday without giving any break. They explained the reason by indicating that they wanted to finish pesticide application as quickly as possible. Also, farmers had no idea on air inversion. For those reasons, it is difficult to say that farmers are sensitive enough against meteorological factors in agricultural pesticide application.

It was determined that 15 farmers (13.6%) made agricultural pesticide application under high pressure with low speed when wind speed was high. It was established that farmers did not use any measurement device determining wind speed, relative humidity and air

Table 4. Effect of relative humidity and wind speed on drift distance at 45 cm spraying height and 20 m/s first exit speed from spraying nozzle (Temperature=24℃; turbulence density=20%, water droplets) (Zhu et al., 1994).

Drop diameter (µm)	Wind speed (m/s)	Drift distance of spraying (m)			
		Relative humidity			
		20%	40%	60%	80%
20	1	0.92*	1.13*	1.95*	4.66*
20	2.7	2.00*	2.33*	3.61*	7.08*
50	1	3.26*	3.68	5.24*	7.71*
50	2.7	8.07*	9.14*	12.19*	16.94*
100	1	1.04	1.03	1.02	1.00
100	2.7	3.14	3.10	3.06	3.00
150	1	0.28	0.28	0.28	0.27
150	2.7	0.84	0.84	0.83	0.81
200	1	0.06	0.06	0.06	0.06
200	2.7	0.167	0.167	0.167	0.167
300	1	0.015	0.015	0.015	0.015
300	2.7	0.045	0.045	0.045	0.045

*Droplets are evaporated before reaching to target surface.

temperature among meteorological data in survey studies made in the field. It was stated that 80% of farmers and application operators had no idea on correct wind speed, relative humidity and temperature values in pesticide application with field sprayer. The most important meteorological factors affecting pesticide application are wind speed and direction, air temperature, relative humidity and, atmospheric stability and reverse air current. Leading factor among meteorological conditions causing pesticide drift is wind speed (Dursun et al., 2004).

Accordingly, if agricultural pesticide application is made under high wind speed by farmers or application operators, spraying drift increases significantly. When wind speed increases, then movement distance of pesticide carried outside the target area and movement distance of these pesticides increase. When a drop falls within air, then surface molecules of water evaporate. This evaporation decreases size and weight of droplets and causes drift to further from the application region. Low relative humidity and high temperature conditions cause rapid evaporation of pesticide droplets and more quantities of pesticide drift. Also, small particles fall slowly in the air and are drifted further by means of air movement. Farmers and application operators within the scope of this study used hollow cone or flat fan nozzles from spraying nozzles which are expressed as traditional type of nozzles. Since these types of spraying nozzles create a wider droplet spectrum in agricultural pesticide applications, small diameter droplets can occur which have high drift possibility (Wolf, 2005).

As seen in Table 4, in applications made with field sprayer, droplets smaller than 100 µm go out of target area by drift and droplets smaller than 50 µm completely evaporate before reaching the target. Operators can nearly minimize pesticide drift in any case by means of taking right decisions regarding atmospheric conditions and equipment according to the application conditions. Hence, farmers or application operators should monitor and make accurate records of weather conditions at pesticide application time both to reduce liability and make better decisions regarding timing of the pesticide application (Wolf and Hipkins, 2004).For that reason, maximum wind speed for pesticide application has been reported as 10 km/h (Piche et al., 2000). Under appropriate wind speed conditions, adherence was increased in pesticide application in the morning, where air temperature was low and relative humidity was high (Kirk et al., 1992; Hoffmann and Salyani, 1996) and for pesticide application in the evening, humidity formed as a result of dew decreased the adherence efficiency of pesticide particles due to surface flow (Hoffmann and Salyani, 1996).

Advanced agricultural pesticides reached country resulting in a waste of pesticides and unnecessary environmental contamination but the technology used for agricultural pesticides has not been upgraded (Abhilash and Singh, 2009). Reports indicate that 70% of agricultural pesticides compared to the farmer's previous practice could be saved changing the design of nozzles of lever operated knapsack sprayers (Nams and T/Nastec, 2005; Mathews, 1998; Stallen and Lumkes, 1990). Farmers and sprayers equipment operators have wrong information that high volumes, high pressure and high doses were perceived as the most appropriate ways for pesticide application (Abhilash and Singh, 2009).

Since the vast majority of farmers never change sealing washers in their equipment, most of the sprayer equipment

leaks (Shetty, 2001). Also, nozzles are normally not replaced and are even enlarged on purpose to achieve higher flow rates. So the distribution patterns of spraying under these conditions are uneven; leaving sections with no pesticide coverage and others receiving overdoses (Nams&T/Nastec, 2005; Matthews, 1998). Development of the application equipment has kept pace to ensure an adequate application of these modern products. However, this development regarding modern application equipment and its professional use was not transferred satisfactorily to field practice (Friedrich, 1996).

Conclusions

In the survey study made in Sanliurfa Province, it was found that farmers and application operators in the region operated crop sprayer under very high application pressure. Within the scope of survey; since farmers operated widely used hydraulic nozzles under 10 bar pressure, field sprayers were used under an operating pressure more than twice of normal working pressure. In herbicide, fungicide and insecticide applications farmers used conventional nozzles and one nozzle type without changing in different applications. Also farmers adjusted application height and calibration of crop sprayer based on their own personal experiences.

Also in this study, producers did not know meteorological conditions required for agricultural condition such as wind speed, air temperature and relative humidity and they decided on pesticide application by trusting their own experiences. According to details obtained within the scope of this survey, farmers or application operators have no sufficient knowledge on agricultural pesticide application. Farmers of the region decide for agricultural protection based on their experiences.

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