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Evaluation of Pesticide Spraying Quality in Wetland Rice Cultivation in Malaysia

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ABSTRACT
The uniformity spray distributions, and labour quality of work were analysed for various operating conditions for two real field operations in wetland rice cultivation in Malaysia. Water sensitive papers used as positioned targets closed to the plant and were compared against known and standard coverage, droplet size spectra and class size distribution verified through manual counting. The results indicate that commonly used nozzle, swath width, nozzle heights, nozzle direction, pressures and labour performance often affect the operation quality and spraying distribution. The result showed that the spraying penetration index of 32.13%, which is 67.87% lesser than the desired penetration ratio. Spray applications distribution showed droplet density between 14 and 108 drops cm2 and a wide range of droplet size spectra. The study shows significant difference in distribution in the field. The higher distribution of very fine droplet (75 -108 droplet/cm^2) was mainly in the area of 0 to 1 metre from 4 edges of the field and 1m left and right the 8 working line, then (61- 73 droplets cm^2) and this in the location 1 to 2 m right and left the working line, the other areas ranges from (14 – 60 droplets cm2). The result shows there are 3.3% is uncovered horizontal area due to labour performance. Most of the operator 71.43% have speed higher than the ideal speed while 28.57% of the operator have speed lower than the idea. 34% of farmers have applied medium sprays, 66% of them have applied finer sprays.

Keywords: Coverage, Penetration, Droplet, Distribution, Swath width

INTRODUCTION

The world rice crop is attacked by more than 100 species of insects; 20 of them can cause economic damage. Insect pests that can cause significant yield losses are stem borers; leafhoppers and planthoppers (which cause direct damage by feeding as well as by transmitting viruses); gall midges, a group of defoliating species (main1y lepidopterans); and a grain-sucking bug complex that feeds on developing grains. Any decrease in pest damage means a corresponding increase in needed rice production.

It is critical that farm managers carefully monitor pest conditions and take action to keep pest levels and damage below economic thresholds. With the selective and timing of applications of new pesticide formulations becoming increasingly important, it is imperative that pesticides to be applied as efficientt as possible when needed. The situation is made more difficult because of the variety of pests and diseases and techniques found in this field (Derksen et al., 2006).

Ensuring a uniform placement of the applied materials (pesticide) to the target (pest) is an important task for the sprayer operator which required careful setting for the sprayer. This factor (spray distribution) which is expressed by the coefficient of variation (CV, %) could influence obtaining the required (maximum) efficiency of chemical crop protection with minimum costs and environmental contamination (Subr et al., 2017).

This paper aims to evaluate the quality of spraying in terms of uniformity of distribution, uncovered area, labor performance and suitability of equipments.

METHODOLOGY

The area of the paddy fields is at Sungai Burung located in the district of Tanjung Karang in the State of Selangor (Latitude: 3°29'0.47 N "Longitude: 101°9'0.56"). Data were collected for two seasons All the spray distribution tests were done during the sprayer was working in the paddy field by measuring the nozzle height, nozzle direction angle, swath width, amount of mixed chemical, operator forward speed, the actual working length, with the weather status, wind direction with or against working direction, wind speed in km/hr., relative humidity (%) , temperature degree (C°). The spray distribution was evaluated by analyzing three parameters: (1) spray deposit on sensitive paper expressed by count the numbers of droplets per unit area (ng/cm^2); (2) spray coverage, which represents the percentage of water sensitive surface covered by the droplets; (3) Penetration index (PI), which enables the spray deposit measured in the whole parts of the plant to be compared with that uncovered part of the plant; (4) uncovered horizontal area. PI (%) was defined in order to analyses the relative deposition between the upper and lower parts of the canopy according to the equation:

$$PI = U/L \times 100$$

Where:

U is the average coverages length at the upper parts of the canopy.

L is the uncovered length at the upper and lower parts of the canopy.

PI was defined and calculated with the aim of evaluating the coverage and distribution of the product that arrives the whole part of the plant and the relation of the distribution uniformity of product deposited in the upper and the lower zones of the crop.

The sampling strategy was designed to enable deposits on water sensitive paper strips in the top, middle and lower parts of the plant canopy and quantified separately. Particular attention was directed at quantifying the ratio between upper and lower leaf-surfaces. Spray deposits on the water sensitive paper strips were quantified by recovering the target horizontally and vertically.

Swath width (working nozzle spacing (m)) was measured by measuring the effective spraying area left and right the operator in every working row. The distance between the operator and the edge of effective area during the operation was taken by using measuring tape. Nozzle type used was record, the height of the nozzle from the ground was measured during the operation by stopping the operator with hold their hand at the working height and measured the distance from the ground and the plant height was measured at ten different locations and the average was calculated, also the nozzle orientation and nozzle working angle and was measured from the horizontal level. The nozzle flow rate was measured by calibration and calculated during the operation which is depending on the volume of used liquid and the time needed to finish of whole volume. Spray volume per hectare was recorded.

RESULT

Distribution & Losses

Selecting Suitable Equipment

For evenly and completed covering distribution farmers should use a suitable nozzle. 63.33% of the farmers use a suitable nozzle for their spraying for the three first applications and 36.67% of them do not use the suitable nozzle. 63.33% of farmers use one type of nozzle (hollow cone nozzle) for spray the plant at all growth stage, this nozzle is suitable for spraying the plant at the early growing stage from emergence till tillering stage because the plant still not too high and the density is medium, but after this stage the nozzle is not suitable the farmers should use standard high pressure flat fan nozzle to achieve 100% of spray penetration ratio. Hollow cone nozzles are generally used where complete coverage of the leaf surface is important, and where a fine spray pattern is needed for thorough coverage. Spray drift is higher with hollow cone nozzles than with other nozzles as small droplets are produced. Full cone nozzles produce large, evenly distributed drops and high flow rates. 100% of the farmer use the smaller tank (200 *l*) than the standard tank (360 *l*) because the local manufacturers made it (200 *l*) and the carrying car cannot hold bigger than this tank. There a lot of pesticides should solute in 300 *l*/ha, and for 1.2 hectares the farmers should use a tank with at least 360 *l*.

Droplet Pattern

From first to the third application (plant age from 9-10 days to 30 -35 days) 34% of farmers have applied medium sprays, 66% of them have applied finer sprays. To minimize drift and contamination of water, the spraying was performed with fine droplet size while it should be done by very fine droplet size because the plant is still short in height (60 -70 cm) and the plant remains in medium density (350 - 370 stem/m^2) and this led to less efficient use of some pesticides. The farmers adjust the nozzle angle to small angle of 40^o, while it is better to wide angle to 90^o for wide range distribution and more fine spray pattern. Larger droplets in coarse or fine sprays may provide inadequate coverage to control pests. As much as 32% of the spray applied to a crop to be lost to the soil during the application.

100% of the droplets pattern at all operation are fixed, the operators do not fit low-drift nozzles to produce larger droplets. From the fourth to the sixth applications ((plant age from 60 days to 84 -90 days) the spraying droplet pattern remains as mentioned above 34% coarse and 66% fine, it should be done by coarser droplet size because the plant is high as (100 -105 cm) and the plant density remains (450 - 550 stem/m^2) in transplanted paddy and (650 - 750 stem/m^2) for directly seeded paddy, and this prevents the fine droplet from penetrating the plant and this lead to less efficient use of pesticides. And as a result of this 23% of the yield was lost due to the plant infection by stem borers which live in the bottom part of the plant and the lack of spraying to reach the target and uses the unsuitable nozzle with low height of spraying with the fine droplet.

Penetration Index

100% of farmers used hollow cone nozzles in spraying their fields. Mean droplet velocities from hollow cone nozzles are lower than those from flat fan designs. As consequence deposits on higher leaves of the paddy canopy were higher than on the bottom leaf and stem. The result shows that the spraying penetration index of 32.13%, which is 67.87% lesser than the desired penetration ratio, and this led to huge losses in the yield calculated to be 23% of the rice yield due to this lack of spraying penetration inside the plant for fighting Stem Borer which live in the bottom part of the plat and damage 23% of the crop. For improved penetration into the crop canopy 80º flat fan nozzles are recommended. (Al-Gaadi, 2010)The tested flat fan nozzles exhibited a better spray distribution and lower error in application rate at all nozzle heights compared to the hollow cone nozzles. Stem borer and brown plant -hoper are more efficientt controlled with a drop-pendant boom at high pressures to penetrate and cover the foliage while borers require a drench using large water volumes at low Pressures applied to the soil. The drenches would generally be applied with flat spray nozzles.

For the late spray, the nozzle height was ranging from 20 cm to 30 cm over the target (plant) 63.3% of spray operation the nozzle height was 20 cm and 37% of spray the nozzle height was 30 cm depending on the labor height. Azimi et al., (1985) found that 66 cm nozzle height above the plant is more effective and efficient than 32 cm. The nozzle height and tilt angle forms the effective nozzle-to-target distance. Greater nozzle-to target distances allow the spray droplets to spread more and create wider individual spray patterns. Also, higher pressures increase the initial spray droplet velocity which causes them to form a wider spray pattern. So the amount of overlap for a certain nozzle is influenced by spacing, height, and tilt angle of the nozzle and pressure at the nozzle. (Azimi et al., 1985).
Unless the pesticide is applied properly it will not produce the good results. Therefore, the quality of the application of pesticides is very important in pest control operations. Adherence to the following points can ensure it: Proper dosage should be applied evenly, the toxicant should reach the target, proper droplet size and proper density of droplet on the target. 23% of the rice yield was lost due to lack of spraying penetration inside the plant canopy for fighting Stem Borers which live in the bottom part of the plant.

Evaluation of Spray Distribution
Water-sensitive papers (WSP) manually counted droplet density (droplets/cm2). The WSP were grouped according the coverage (droplets/cm2): poor (1-19%) Medium (20-39% and excellent (40-100%). The result showed distribution coverage ranging from Poor to Excellent (Table 3). Spray parameters related with droplet density/cm2 spectra showed an overall ranged from Fair to Moderate. There was a great difference between droplet densities measured. The result showed highest droplet density coverage equal 100% and 94%. There are excellent coverage equal to 55.35, 47.06, 44.06 and 42.26%, low coverage from 15% to 1%. The water sensitive papers showed uncovered area especially at the vertical level where more than two-thirds of the plant height is not covered (67.87%). Spray applications distribution showed droplet density between 14 and 108 drops cm2 and a wide range of droplet size spectra. The study shows significant difference distribution in field. The higher distribution very fine (75 -108 droplet/cm2) was mainly in the area 0 - 1 metre from 4 edges of the field and 1m left and right the 8 working line, then (61- 73 droplets cm2) and this in the location 1 to 2 m right and left the working line, the other areas ranges from (14 – 60 droplets cm2). In overall, there are 31.19 % very high and excellent covered, 30.51% covered with good and satisfy distribution, 25% sprayed with insufficient amount of chemical and 3.3% of plant considered as uncovered are.

Control Drift
Reducing pesticide spray drift and maximizing efficacy are the paramount considerations when selecting technologies and operating parameters prior to making an application. Spray drift increases with the wind, in low humidity and when small droplets comprise the majority of the spray (Bouse et al. 1990), making nozzle selection of the utmost importance to any spray drift management procedure. Droplet size can also influence the rate of on-target deposition as well as canopy penetration (Spillman 1984) with smaller droplets providing better deposition and canopy penetration than larger ones, also influenced by plant structure (Miller et al. 2000). 100% of the operator do not avoid spraying on still warm days so convection currents cause drift in unpredictable directions. 79% of the operators spray the chemical within allowable range and 50% of this percentage work within the optimum wind speeds which are between. 44.71% of the operators do not cancel the operation or delay it because the wind speed is high and they do not avoid spraying on a windy day, while 55.29% of them avoid spraying on a windy day. 65.8% of the farmers follow the standard and do not spray in still warm days, as 34.24% of them do not delay the operation on still warm days.
51.84% of the operators reduced the nozzle height when they see that there is much drift, while 48.20% do not care and continue spraying anyway spray the crop at the same nozzle height and do not reduce nozzle height if they work against wind direction. 100% of the farmers do not delay the operation due to the high humidity weather they just do that if the rain is falling Table 1.
Every operation 50% of spraying performed in the same direction of the wind while the other 50% of the spraying is done against wind direction and that because the operator work in rounded pattern.
100% of the operator spray the crop using the same nozzles during all operation and do not use drift nozzles to avoid drift. 63.33% of farmer's controls limit drift of sprays outside treated areas by the introduction of no-spray zones (water canal) by spraying from the edge to inside the field, while 36.67% of the farmers tend to spray from inside the field to edge of the field which leaded to outside drift.

Timing, amount and type
Accurate spray timing of the adequate amount of the effective and suitable active ingredient with perfect and even distribution avoiding drift and the

uncovered area will ensure that the product is applied with optimum effect. There are many factors and practices that negatively affected the spraying operation quality; when the decision to use the pesticide is made there is no considering of the effect of the selected pesticide product on the target and environment; The farmers do not make a pre-spray field survey to highlight surrounding areas of infected plant, the pest type, the infected plant area they do not located and map these objects.

Sprayer Ground Speed

Knowing the travel speed and maintaining a constant rate are crucial to good calibration and application. Speed of operators varies from one to another. Some labor has very fast speed during the application while other has a wise speed.

Compares the operator speed with ideal speed that calculated from calibrated Power Sprayer, most of the operator 71.43% has speed higher than the ideal speed which leaded to spray amount less than the whole solute chemical and remain amount average between 10 liter and 8 liter in the chemical container and that effect the efficiency of pesticides operation and the quality of work because the whole amount of chemical in the container was calculated to depend on the label and should be sprayed all in the farm evenly, beside, the remaining amount stays in the container till nearest application or poured on the land which harms the environment. On the other hand, 28.57% of the operator have speed lower than the ideal speed which always made the operator finished spraying the overall chemical before covering all the field what forced the farmer to add water to the remain chemical to cover unsprayed area in the field and that also leaded to deficiency of pesticide application and lack of work quality due to the concentration of the extra amount of chemical has not the same amount of ingredient concentration that most of the field had and the label included.

Table 1. Farmer Practices to Control Spraying Drift

Factor	Follow	Not follow
Avoid spraying on still warm days	65.8±0.84 %	34.24±0.69%
Avoid spraying on windy days	55.29±0.89%	44.71±0.44%
Reducing nozzle height	51.84±0.42%	48.20±0.38%
Reducing pressure and using larger nozzles	43.44±0.54%	56.57±0.55%
Fit low-drift nozzles.	33.51±0.55%	66.49±0.76%
Change current nozzle by drift nozzle	Zero%	100%
Using of no-spray zones	63.33%	36.67%

Table 2. Field and Climate Condition During Operations

Factor	Follow Standard	Not Follow
Wind speed km/hr.	63.33%	36.67%
Air speed at outlet km/hr.	63.33%	36.67%
Wind direction	50%	50%
Temperature C0	0%	100%
Humidity %	0%	100%
Water depth (cm)	64%	36%
Irrigation Water Closure	75%	25%
Irrigation water leakage	64%	36%
Operation day time	33.33%	66.67%

Table 3. Effect of pesticide operations on crop condition

Factor	Before Operation	After operation
The plant damage by pest/m2 %	9.34±0.43 %	8.94±0.15%
Weedy rice plant in rice field/m2 %	11.19±0.31 %	6.16±0.08 %
Weed extent in rice field	3.22±0.06 %	2.06±0.07%

Table 4. Statistics of coverage and droplet size spectra obtained by manual counting for the WSPs grouped according the coverage density

Spray parameters	Poor		Medium		Dense	
	Min	Max	Min	Max	Min	Max
Area Coverage %	3.9	19	20	40	41	100
Drop Density(droplets/cm^2)	15.8	22.5	26.4	47.8	63.1	109.2

4. Conclusions

Poor distribution uniformity may be caused by improper nozzle mounting geometry and insufficient overlap of the spray from the individual nozzles. Spray uniformity is also dependent upon the individual spray pattern profiles. The shape of the spray pattern profile of an individual nozzle depends partly on the type and capacity of the nozzle utilized which in turn is influenced by the pressure at the nozzle, the height of the nozzle from the spray surface, and the angle at which the nozzle is oriented. Ensuring a uniform placement of the applied materials (pesticide) to the target (pest) is an important task for the sprayer operator which requests careful setting for the sprayer.

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