RESEARCH ARTICLE

ASSESSMENT OF APPLICABILITY AND EFFICACY OF POST EMERGENCE HERBICIDES THROUGH VARIOUS NOZZLE SYSTEMS IN WHEAT (TRITICUM AESTIVUM L.)

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ABSTRACT

In India, the potential yield losses due to weeds in wheat are estimated up to 50 per cent depending upon degree of weed infestation, weed species and management practices. Due to improper application and stage, losses of herbicides increased manifold, be fond of significant reduction in crop yield with adverse effect on soil health. Nozzles used by farmers for herbicide spray, play a vital role in efficacy of herbicides. The efficacy of different nozzle systems viz. hollow cone, even flat fan, twin orifice flat fan, and full cone were assessed for the application of post emergence herbicides in irrigated wheat with a control treatment. The herbicides i.e. sulfosulfuron and 2,4-D were applied after 25 days after sowing of the crop, cv. HD 2864. Sprayer nozzle performance was evaluated in terms of weed density (m-2), weed biomass, plant height (cm), number of effective tillers/plant, grains/spike, wheat grain yield and wheat straw, at farmers’ field in Katni district of Madhya Pradesh during 2007-08 and 2008-09. Statistical analysis indicated that the nozzle type had significant effects on grain yield and dry biomass of weeds. The results revealed that the knapsack sprayer fitted with twin orifice flat fan nozzle for herbicide application, gave better weed control due to its comparatively less spray drift than the others. The weed density was observed highest in the herbicide applied using hollow cone nozzle due to its fine droplet size responsible for high spray drift and lowest in twin orifice flat fan nozzle followed by even flat fan and full cone nozzles respectively. The weed control efficiency of herbicides applied through full cone nozzle was also higher than the hollow cone nozzle. The yield attributes, grain and straw yield of wheat was noted high with twin orifice flat fan nozzle due to its better herbicide efficacy.

INTRODUCTION

Weed management is an ever-present challenge to crop production. Weeds have the potential to usurp resources that would otherwise provide nourishment to growing crops or interfere with planting or harvesting operations. Because of these potential negative impacts, much research has been devoted to developing management strategies aimed at reducing weed populations, usually through mechanical disturbance or chemical applications (Zimdahl, 2004). Weeds are always associated with human endeavors and cause huge reductions in crop yields, increase cost of cultivation, reduce input efficiency, interfere with agricultural operations, impair quality, act as alternate hosts for several insect pests, diseases and nematodes. Weeds compete with crop plants for various inputs like water, nutrients, sunlight. The importance of their management seldom requires any mention especially under the present day high input farming systems. Weeds also interfere in the management of all the terrestrial and aquatic resources, create problems in the maintenance and inspection of various defense, electrical, railway and airport installations besides being a potential fire hazard in forests and cause health hazards like skin allergy, nasal diseases, etc.

The impact of weeds on the Indian economy estimated about two decades ago ranged from Rs. 20 to 28 billion (Sachan 1989, Sahoo and Saraswat 1988). A recent study suggests that proper weed management technologies, if adapted, can result in an additional income of Rs. 1,05,036 crores per annum (NRCWS, 2007). This figure would be greater if the direct and indirect impact of weeds on aquatic systems, forestry and industrial sites are also included. At a conservative estimate, an amount of Rs. 100 billion is spent on weed management annually in India, in arable agriculture alone. The potential yield losses due to weeds can be as high as about 65 per cent depending on the crop, degree of weed infestation, weed...
species and management practices (Yaduraju et al., 2006). Weed management is as old as agriculture itself, but the methods and concept of controlling weeds have changed over the years. The present weed control practices in India are characterized by intensive use of manual labour and animal power. Both of them are in short supply and are increasingly becoming uneconomical. Manual weeding, besides laborious is inefficient (not done on time in most cases) and always not practical because of adverse soil conditions. In addition, the manual labour traditionally being employed for weeding is gradually becoming scarce and expensive owing to rapid urbanization and industrialization. It has been noted that proportion of economically active population engaged in agriculture decreased from 64% in the year of 1990 to 57% in 2005 (IASRI, 2008). The weeds are more competitive with crops during the initial stages of their growth (2-6 weeks after planting). Controlling weeds during this time is very essential for realizing maximum crop yield. Because of this, chemical weed control method is rapidly gaining ground in the country, which on the other hand is raising several environmental concerns.

Currently wheat and rice crops account for about 60 and 20 per cent respectively of the total herbicide consumption in the country, the third crop being soybean which accounts for about 4 per cent. The data on herbicide consumption shows that they are being used in approximately 20 million hectares, which constitute about 10 per cent of the total cropped area (Yaduraju et al. 2006). Wheat production is directly affected by several factors and one of the most limiting is the problems of weeds. Yield losses of this crop estimated by researchers which varied between 30-50 per cent based on weed infestation (Pandey et al., 1997). Crop suffers stress created by weeds through competition for moisture, nutrition, space, light and many other growth factors through competition and allelopathy. These tend to persist while man's efforts for eradication, resulting in direct loss to quantity and quality of the produce (Qasim and Foy, 2001; Gupta, 2004). Keeping in view the scarcity and high wages of labour, particularly during the peak period various post emergence herbicides are being used to control weed species in wheat crop and maximizing the seed yield (Singh et al., 2003; Pandey et al., 2006). The application of herbicidal mixture may be useful for the control of diversified broad and narrow leaved weed flora (Panwar et al., 1995, Singh et al. 2006).

Katni, a district of Madhya Pradesh state falls under Kymore plateau and Satpura hills agro climatic zone of the state. The zone is characterized by mixed red to medium black soil with silty clay to sandy loam in texture. Paddy and wheat are the main crops of kharif and rabi season with an area of 106800 and 65000 ha out of seasonwise total cultivated area of 137800 and 127200 ha respectively. Major weed species of wheat commonly observed are Phalaris minor, Cynodon dactylon, Avena ludoviciana, Lathyurus aphaca, Vicia sativa, Echinocloa colona and Chenopodium album. Out of the above, most noticeable weed species are Phalaris minor and Lathyurus aphaca and Chenopodium album with respect to weed density. At present, application of herbicide in wheat is being practiced in about one third of its total area for controlling weeds and to enhance the grain yield in the district, but the method of herbicide application to maximize the efficacy of various herbicides either alone or in combination against the grassy and broad leaved weeds in wheat crop, is still lacking. More than 85% farmers use ‘knapsack sprayers’ for spray of herbicides. The hollow cone nozzle fitted in the sprayer at the time of purchase, is commonly used for spray of pesticides and herbicides which affects the efficacy of herbicides in particular. Spraying parameters, such as spray volume and type of nozzle, play an important role in weed control effect because of their influence on covering and distribution of spray solution on plants surfaces (De Snoo & De Wit, 1993; Stainer, et al., 2006). So, keeping in view the present study, was therefore, planned and conducted to find out the appropriate weed management options through various nozzle systems to maximize the herbicide efficacy for obtaining higher grain yield of wheat crop at farmers’ field in Katni district.

MATERIALS AND METHODS

The proposed study was conducted at selected farmers’ field of Katni district (Madhya Pradesh) in rabi season during 2007-08 and 2008-09. The crop was sown during 3rd to last week of November 2007 and 2008 respectively on the mixed red soil prevalent in the area. HD 2864 variety was used with a seed rate of 100 kg ha⁻¹. The soil was ploughed at desirable field condition and followed by single planking. Nitrogen (N), phosphorus (P) and potassium (K) were applied @ 100:60:40 kg ha⁻¹ in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP) respectively. Whole P, K and half of the N were side dressed at the sowing time, while remaining N was top dressed in two splits after first irrigation and flowering stage respectively. The crop was irrigated five times as the first irrigation was done 21 days after sowing and subsequent irrigations were applied as per crop water stages especially at tillering, pre-flowering, milking and grain development stage. All other agronomic practices except those under study were kept normal and uniform for all treatment combinations. The crop was harvested manually at physical maturity in II fortnight of April, 2008 and 2009. The trial was laid out at farmers’ field (0.2 ha each) at five locations and farmers were treated as replications.

The experiment comprised five treatments viz. T₁ – no weed control, T₂ – weed control by post emergence herbicide application through hollow cone nozzle, T₃ – even flat fan nozzle, T₄ – twin orifice flat fan nozzle and T₅ – full cone nozzle. The post-emergence herbicides i.e. sulphosulphuron @ 25 g a.i. ha⁻¹ and 2,4-D @ 0.5 kg a.i. ha⁻¹ were sprayed at 25 days after sowing of wheat crop in moist field by “knapsack sprayer” using the above nozzles. Volume of spray was maintained uniform in all treatments and water was used @ 350 L ha⁻¹. Herbicide application was done in the morning, when wind was not blowing (wind was not moving leaves of surrounding trees) and spray height was maintained at a lower level of 30 to 40 cm above the ground. Data for weed density (m⁻²) was recorded at 30 to 60 days after sowing (DAS) using standard procedures during the course of study. The counted weeds were cut near ground surface, stored in polythene bags and then recorded their biomass. The dry weight of weed was determined after oven-drying at 70°C till constant weight was
achieved. The parameters viz. plant height (cm), number of effective tillers/plant, number of grains per spike, 1000 grain weight (g), grain yield (q ha\(^{-1}\)) and straw yield (q ha\(^{-1}\)) were recorded. Data was analyzed statistically according to Fisher’s analysis of variance technique (Steel et al., 1997) and least significant difference (LSD) test at 5% probability level was applied to compare the treatments’ means.

RESULTS AND DISCUSSION

Effect on weed density

It is evident from Table 1 that, under T\(_1\) (no weed control), highest weed density (36.9 and 48.5 m\(^{-2}\)) was recorded at 30 and 60 DAS respectively. Among those treatments where herbicide was applied, maximum weed density (17.5 and 18 m\(^{-2}\)) was observed in T\(_2\) (hollow cone nozzle) both at 30 and 60 DAS followed by full cone, even flat fan and twin orifice flat fan nozzles respectively. Significant reduction in weed density was noticed in all the preceding treatments over T\(_2\). The higher weed density in case of hollow cone nozzle was due to its fine droplet size and highest drift potential reduced the efficacy of herbicides. These findings are in agreement with those of Miller and Bellinder (2001) who have reported that hollow cone nozzles create fine spray because of fine droplet size which is responsible for highest drift potential.

Effect on weed dry weight

The data given in Table 1 indicates that the nozzles evaluated for herbicide application were significantly reduced weed dry weight over control (no weed control). Under the herbicide application treatments, maximum weed dry weight (12.23 m\(^{-2}\)) was noted in hollow cone nozzle, however, the minimum weed dry weight (1.92 m\(^{-2}\)) was found in the fields where twin orifice nozzle was used for herbicide application. Less weed dry weight in case of twin orifice nozzle was noted due to less drift and higher herbicides accumulation in weed leaves resulted fast killing action as the height of spray was done at lower level above the ground. This observation is in agreement with findings of Jong et al. (2000) who reported that lowering the height of a boom sprayer from 70 cm to 30 cm reduced drift by 80% which, in turn, maximized the herbicide efficacy.

Effect on weed control efficiency

The data pertaining to weed control efficiency revealed that it was observed to be maximum (93.63 %) in twin orifice nozzle was used for herbicide application followed by even flat fan nozzle (90.34%). Under the T\(_2\) treatment (full cone nozzle) weed control efficiency was noted to be 78.66 per cent, while, the minimum value was noted in case of hollow cone nozzle (59.41 %). The poor weed control efficiency of hollow cone nozzle was probably due to fine smallest droplets nearly of mist form increased the drift as the spray unintentionally reached outside the target area as fine droplets. These findings are similar to the research of Nuyttens et al. (2007) has reported that the mean droplet size may vary between the different nozzles at a similar spraying pressure. Nuyttens et al. (2006b) reporte that the variation in drift between different nozzles under standard weather conditions can be even larger. Similar results were also reported by De Snoo and De Wit (1993) in their research trials conducted on drift estimation of pesticides sprayed by knapsack sprayers to ditches and ditch banks that nozzle type also affects the spraying angle, which on its turn may have an impact on drift.

Effect on yield attributes and yield

Significantly superior values under all the treatments were observed for plant height (cm), number of effective tillers/plant, grains per spike, and 1000 grain weight (Table 2)
as compared to control. Among the herbicide application treatments, highest values of these parameters were noted in T4 (twin orifice flat fan nozzle), however, the lowest in T2 (hollow cone nozzle). The nozzles assessed for herbicide application, significantly influenced the grain and straw yield of wheat over control. The extent of increase in grain yield was noted to be 13.64, 28.34, 37.45 and 22.73 per cent in the preceding treatments over control. The straw yield was increased by 9.38, 21.68, 25.14 and 17.51 per cent with preceding treatments over control. Twin orifice nozzle was most superior with respect to weed control as a result of that highest grain and straw yield of 41.91 and 66.96 q ha\(^{-1}\) respectively noted with the said treatment (Table 2). The hollow cone nozzle showed poor performance in herbicide efficacy among all the nozzles, hence the lowest grain and straw yields (34.65 and 58.53 q ha\(^{-1}\)) were recorded. The findings are similar to those of Renata, K. and Krzysztof, D. (2013) who has investigated two types of nozzle for spray of herbicide formulations in winter wheat which showed that the spray performed by extended range flat nozzle resulted in better herbicide efficacy due to size of droplets and uniform distribution on plant surface.

Economic analysis

It is evident from Table 3 that the net return and BC ratio were recorded to be highest in T4 (twine orifice flat fan nozzle). An additional net return of Rs 11565 ha\(^{-1}\) was found with the said treatment which leads to a remarkable difference (0.78) in BC ratio over control. These results show the efficacy and suitability of the twine orifice flat fan nozzle for herbicide application. Even flat fan and full cone nozzles were also stemmed remarkable difference in net return and BC ratio over control. The net return under T2 (hollow cone nozzle) was, however, higher as compared to control but the BC ratio was same due to increased cost of cultivation which is indicative of its poor herbicide efficacy thus the use of hollow cone nozzles practiced by the farmers for herbicide application is unsuitable, hence it should be avoided for the above purpose.

On the basis of above results, it may be concluded that the type of nozzles for spray of post emergence herbicides in wheat, may create significant difference in terms of herbicide efficacy which influences weed density and as a result of that yield is significantly affected. Hollow cone nozzles proved high spray drift resulted in poor herbicide efficacy and less weed control efficiency; hence the study suggests inappropriateness of above nozzle for herbicide application. Twine orifice flat fan nozzle performed well for post emergence herbicide spray followed by even flat fan and full cone nozzles.

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