Original Research Article

Impact of herbicides on yield of direct-seeded rice and microbial population in soil

ABSTRACT

The herbicides used in direct-seeded rice (DSR) may be change the soil's biotic balance, which could have an impact on the soil nutrient status, health, and productivity. During *Kharif* season 2016 and 2017, the field trials were carried out using 14 treatment combinations at Agriculture Research Farm of BAU, Sabour, Bihar, India. The findings showed that the various weed management methods used during both years had variable effects on the viable microbial community. The Bispyribac-Na 30 g *a.i.* ha^{-1} applied as a post-emergence (PoE) and Pendimethalin 1000 g. a.i. ha^{-1} applied as a pre-emergence (PE) significantly improved by 121.71% and 134.08% and 74.59% and 91.33% actinomycetes population after compared with weed free and weedy check, respectively at 90 days after sowing (DAS). Whereas highest grain (6667 kg ha^{-1}) and straw (9777 kg ha^{-1}) yields and harvest index (HI) (40.54%) was observed under Bispyribac-Na 15 g *a.i.* ha^{-1}*fb* one hand weeding (1HW) at 40 days and was statistically at par with Azimsulfuron 17.5 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS. The herbicides, viz. Almix, Ethoxysulfuron, Bispyribac-Na and Azimsulfuron as PoE and Pendimethalin and Pyrazosulfuron as PE were innocent for soil microbial populations at recommended dose.

Keywords: Direct-seeded rice, Herbicides, Growth, Microbial population and Yield

INTRODUCTION

Rice (*Oryza sativa* L.) is primarily grown through transplanting of seedlings. This practice requires a greater number of labour engagement for transplanting and weeding and need about 150 ha-cm of water up to harvesting stage (Mahajan and Chauhan 2016). More labour is required for manual transplanting and labour shortages during the monsoon season push farmers to switch to direct-seeded rice (DSR) as a crop establishment method for rice cultivation (Choudhary 2017, Choudhary *et al*. 2017). It provides a number of benefits over rice transplanting, including the need for 35–77% less water and 67% less labour. In addition to these advantages, DSR has lower machine usage requirements and reduce the methane emission levels (Chauhan *et al.* 2012). "Though, weeds constitute a significant biological restriction in DSR, primarily as a result of the deficiency of water impoundment at crop development, therefore crop production and weed management are essential for enhancing rice productivity" (Chauhan 2012). It has been estimated that weeds reduce rice harvest by up to 71-96% in the Philippines (Chauhan and Johnson 2011), 95% in India (Naresh *et al*. 2011). By 2035, it is predicted that an additional 114 million tonnes of milled rice must be produced to meet the world's demand, representing a 26% increase over the subsequent 25 years (Kumar and Ladha 2011). India has to increase its rice output by 3% annually to maintain its current level of food self-sufficiency and to fulfill the nation's future food needs, but the likelihood of increasing the planted area of rice in the near future is insufficient. Long-term research revealed a deteriorated trend in rice yield, although rice production has stagnated in recent years. DSR is becoming more and more popular across the nation as a result of factors such a declining water table, growing labor costs for paddy transplanting, and the damaging impacts of puddling on soil qualities. However, weeds are the biggest obstacle for farmers who cultivate rice via direct sowing, therefore using pesticides both before and after emergence is necessary for a successful harvest and its yield. The use of herbicides may have unintended consequences that affect the microbes ecological stability in the soil and the productivity of soils, including significant changes in the populations of microorganisms and their activities (Min et al. 2002; Saeki and Toyota 2004). Herbicides may have some unintended consequences on species that are not their intended targets when applied to soil. As a result, there has been a lot of interest in how herbicides affect the microbial processes and soil microflora. The activity and biomass of the microorganisms are related to the effects of these substances on specific variables (Wardle and Parkinson 1991). Concerns concerning herbicides' ecotoxicological behavior in the environment of rice fields have grown as their use in rice farming becomes more prevalent. Microbial diversity and soil health have emerged as critical challenges for sustainable agriculture. The functional stability of the soil microbial community and soil health can be impacted by microbial biodiversity loss. Herbicides typically have some detrimental effects on species composition or population density. The herbicide application effects on soil microbial communities were investigated, and counts of bacteria, actinomycetes, and fungi were analyzed. This experiment was done to evaluate the number of these microorganisms at various stages of crop growth following their application two PE and four PoE herbicides are used in DSR for chemical weed management.

METHODS MATERIALS

The field experiments were conducted during *Kharif* Season 2016 and 2017 at Agriculture

Research Farm, BAU, Sabour, Bhagalpur, Bihar (longitude $87^{o}2'42''$ East and latitude $25^{o}15'40''$ North at altitude of 46 meters above mean sea level. The soil at the experimental site had a loamy sand texture, was electrically neutral, had a low organic carbon content, and was medium in available P_2O_5 and K_2O. The experiment was laid out in randomized block design with fourteen treatment combinations, *viz.* alone application of Pendimethalin and Pyrazosulfuron were applied as pre-emergence while other herbicides as post- emergence at 20 (DAS) of crop *i.e.* Pendimethalin 1000 g *a.i.* ha^{-1} (T_1), Pendimethalin 500 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS (T_2), Almix 4 g *a.i.* ha^{-1} (T_3), Almix 2 g *a.i.* ha^{-1}*fb* 1HW at 40 DAS (T_4), Ethoxysulfuron 15 g *a.i.* ha^{-1} (T_5), Ethoxysulfuron 7.5 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS (T_6), Pyrazosulfuron 25 g *a.i.* ha^{-1} (T_7), Pyrazosulfuron 12.5 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS (T_8), Bispyribac-Na 30 g *a.i.* ha^{-1} (T_9), Bispyribac-Na 15 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS (T_{10}), Azimsulfuron 35 g *a.i.* ha^{-1} (T_{11}), Azimsulfuron 17.5 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS (T_{12}), weed free (T_{13}) and weedy (T_{14}) replicated in thrice. The 'Rajendra Mahsuri-1' variety of rice were seeded on begin of second fortnight of June 2016 and 2017 in both the years and tractor drawn conventional seed drill used with 30 kg ha^{-1} seed in 20 cm rows spaced. For the plant protection measures like disease, pest management and essential fertilizer dosage were used. By employing a manual backpack sprayer with a flat fan nozzle and 300 liters of water per hectare, herbicides were applied.

RESULT AND DISCUSSION

Microbial population: The counts of bacteria, fungi and actinomycetes were significantly affected by various herbicides at 90 DAS of the crop (Figure 1). Among all the treatments, significantly lower counts of fungi, actinomycetes and bacteria were found in the weed free and weedy check but in case of herbicides plot significantly higher microbial populations were recorded at both the stages of examine might be due to healthy and favorable environment for the microorganisms as compared to the control. Additionally, more root exudation which are the carbon source for microbial multiplication and their growth. It may be increase in the biological properties and physical conditions of the soil in well aerated aerobic soil conditions found in DSR hence might be credited to the improvement in the nutrient status which resulted in better growth of the microorganisms. The microbial growth takes a decomposed herbicides as carbon source utilize them as a source of biogenic elements for their own physiological processes (Bera *et al*., 2013). Though, toxic effects of herbicides on microorganisms without its degradation, or reducing their population, activity and accordingly, their divers' communities.

The application of Bispyribac-Na 30 g *a.i.* ha^{-1} PoE and Pendimethalin 1000 g *a.i.* ha^{-1} (PE) significantly improved by (121.71% and 134.08%) and (74.59% and 91.33%) actinomycetes population whenever, compared with weed free and weedy check plot, respectively at 90 DAS. It could be as a result of the breakdown of herbicides acting as a carbon source for microbial development and aggressive plant growth with higher root biomass, which causes the secretion of additional carbon molecules to root system. According to Lynch (1983) herbicides are broken down by bacteria during metabolic and co-metabolic processes, which are when adaption phenomena occur. Herbicide metabolites are used to create new chemicals. Herbicides could provide bacteria with food (Cook and Hutter, 1981) in which case they significantly affect microbial growth and multiplication. When compared to the crop's 90 DAS, the microbial count at harvest stage was lower. It could be because less root exudate is secreted, which serves carbon as a source for the development and reproduction of microorganisms in the rhizosphere and early consumption of carbon from the decomposition of herbicides. At harvest time, all pesticide treatments had higher microbial populations than weed-free and weedy treatments, including bacteria, actinomycetes, and fungus. It could be because there is more carbon available from herbicide breakdown and root exudation. It was also implied that the microbial count began to recover after the herbicides, which had also killed the weeds and interacted with the soil's nutrients. (Bhatt *et al*., 2014 and Omara and Ghandor, 2018). Herbicide breakdown might act as a carbon source for the development of bacteria. These outcomes were in tune with outcomes of Jarvan *et al*. (2014). In subsequent stages, the bacterial population in herbicide-treated plots was more or less comparable to the unsprayed control plots, showing that herbicides do not have a negative impact on the health of the soil at applied dosages. Anderson (2003) revealed that, except from at concentrations above advised rates, herbicides typically don't seem to have a negative impact on the overall bacterial community in soil.

Yield: "The data is evident from the figure 2 among all herbicides the application of Bispyribac-Na 15 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS maximum grain yield produced to the tune of 104.6 per cent over weedy check and was statistically at par with Azimsulfuron 17.5 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS significantly superior over rest of the treatments". [28] Likewise, outcomes were similar with the conclusions of Sanodiya and Singh (2017) and Yadav *et al.* (2009). "The rise in yield with used of Azimsulfuron 17.5 g *a.i.* ha^{-1} *fb* 1HW 40 DAS (PoE) was to the tune of 93.3 per cent over weedy check, respectively. Pyrazosulfuran 25 g *a.i.* ha^{-1} (PE), Pendimethalin 500 g a.i.

ha^{-1} (PE) *fb* 1HW at 40 DAS, Pyrazosulfuran 25 g *a.i.* ha^{-1} (PE) *fb* 1HW at 40 DAS and almix 4 g ha^{-1} PoE exhibited statistical at par with each other in terms of lower grain yield among herbicides treatment and produced 39.0, 44.6, 50.7 and 52.6 per cent additional yield than that of weedy check. The lowest grain yield (3258 kg ha^{-1}) was noticed in weedy check. Weed free check also verified highest straw yield (9838 kg ha^{-1}) followed by Bispyribac-Na 15 g a.i ha^{-1} *fb* 1HW at 40 DAS (PoE) and Azimsulfuron 17.5 g a.i ha^{-1} *fb* 1HW at 40 DAS (PoE). The minimum straw yield was observed in weedy check which noted inferior value which was mainly due to reduced dry matter accumulation in plant". Singh *et al.* (2010).

Harvest index: Due to integrated weed management techniques, the HI did not change significantly. Harvest index of DSR ranging from 39.92 to 40.78% presented in figure 2. The uppermost HI was observed in weed free treatment among all the treatments whereas lowermost HI was recorded in weedy check. However, among herbicides treatment, application of Bispyribac-Na 15 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS and Azimsulfuron 17.5 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS, recoded maximum HI respectively. Similarly, outcomes were notices with the work of Sanodiya and Singh (2017).

CONCLUSION

It may be finally concluded that, the application of Bispyribac-Na 15 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS found uppermost straw yield, grain yield and HI and statistically at par with Azimsulfuron 17.5 g *a.i.* ha^{-1} *fb* 1HW at 40 DAS whereas, herbicides treated plot microbial counts were more or less similar to the weed free and weedy check plots thus demonstrating that application of herbicides have no detrimental effect on soil health.

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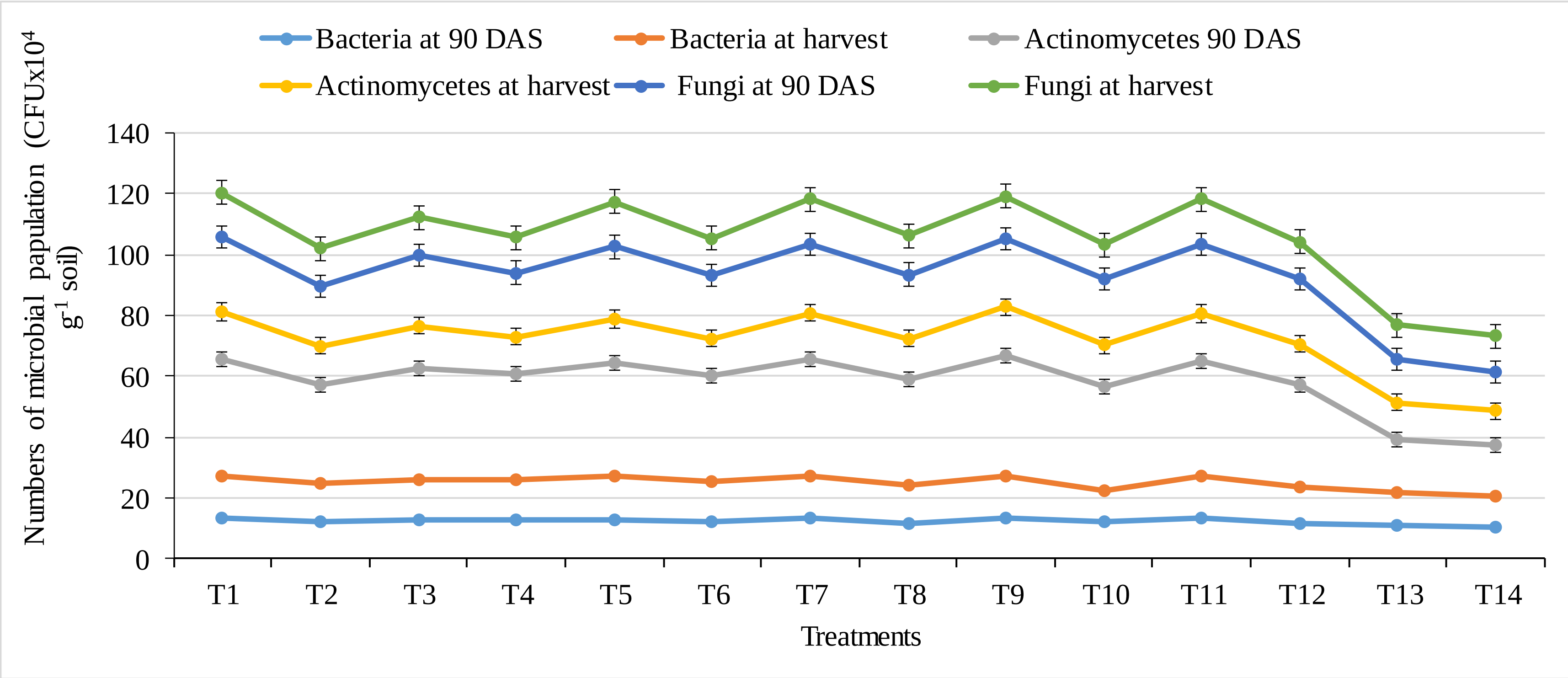

Figure no. 1: Impact of herbicides treatments on microbial population of soil under DSR (Pooled data of 2016 and 2017)

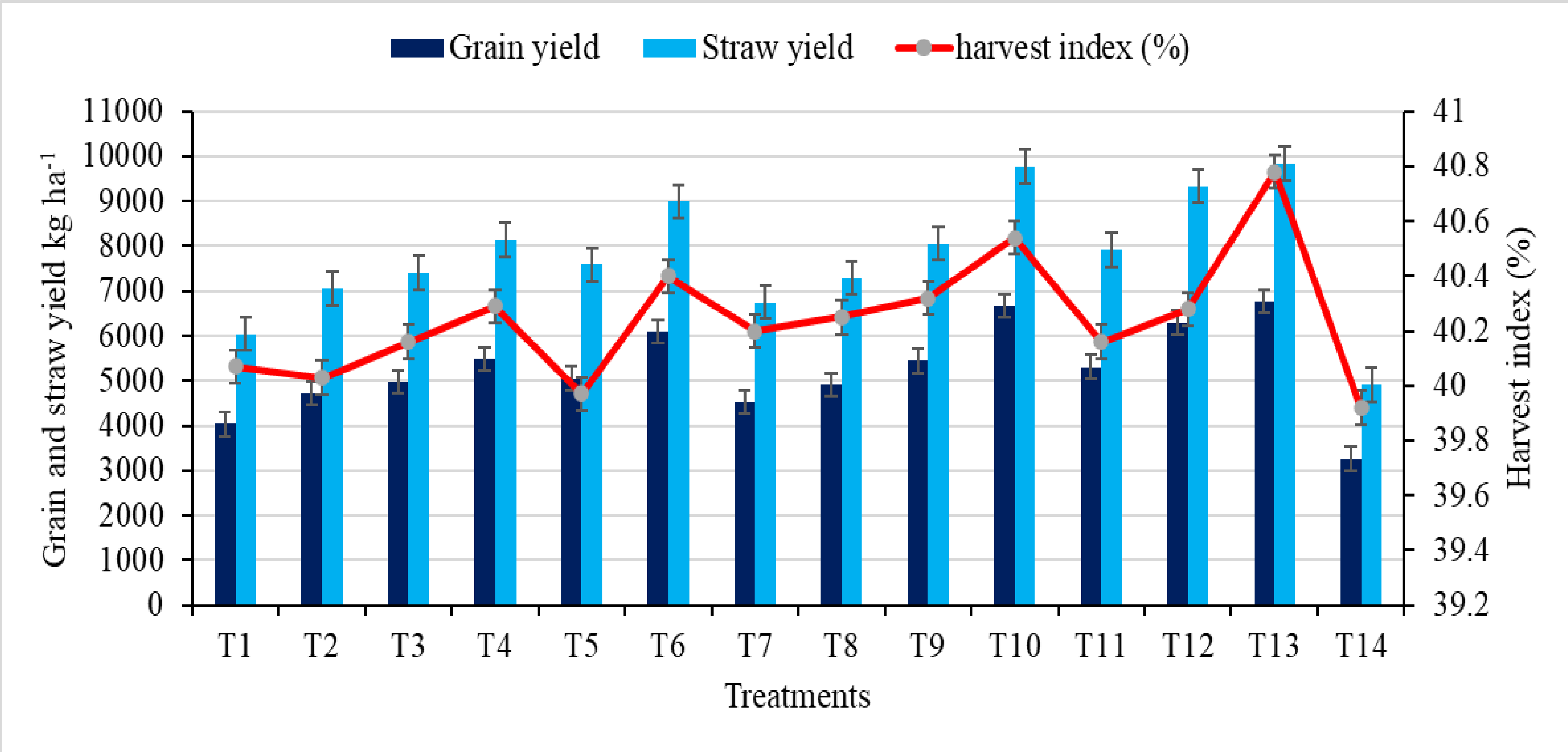

Figure no. 2: Impact of various herbicides treatments on grain yield, straw yield and HI in DSR (Pooled data of 2016 and 2017)