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Effect of Crop Establishment Methods and Weed Management Practices on Weed Density and Productivity of Basmati Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Present experiment was conducted to study the effect of crop establishment methods and weed management options on weed dynamics and performance of Basmati rice.
Study Design: Split plot design.
Place and Duration of Study: Iinvestigation was conducted during the *kharif*-season of 2019 and 2020 at Crop Research Center, S.V.P.University of Agriculture &Technology, Meerut (U.P.), India.
Methodology: Mainfactors consist of the crop establishment methods*viz.*(1) Conventional Puddled Transplanting, (2) Unpuddled Flat and (3) Furrow Irrigated Raised Beds, the sub factors consist of five weed management options *viz.,* (1) Pretilachlor @ 0.75 Kg ha^{-1} PE *fb* Bispyribac sodium @ 20 g a.i. ha^{-1} POE at 20 DAT, (2) Almix 4 g a.i. ha^{-1} + Bispyribac sodium @ 20 g a.i. ha^{-1} POE at 20 DAT, (3) Bispyribac sodium @ 25 g a.i. ha^{-1} POE at 20 DAT, (4) Two hand weedings and (5) Weedy check.
Results: Minimum total weed density was recorded under CPT (E_1) followed by FIRB(E_3) while itwas maximum under UPF(E_2). Two hand-weedings effectively reduced total weed density. In herbicides, application of pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1} (W_1) was

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found most effective in reducingtotal weed density.Higher yield and yield attributes were found under CPT which was significantly higher than the UPF and at par with FIRB. Amongweed management practices highest yield and yield attributes were obtained with pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1}.Lowest yield and yield attributes were obtained in weedy check.

Conclusion: Puddled transplantation in rice might be the best option to get higher yield and for weed control, application of Pretilachlor @ 0.75 Kg ha^{-1} PE *fb* Bispyribac sodium @ 20 g a.i. ha^{-1} POE at 20 DAT may be done to get higher yield.

Keywords: Almix; basmati rice; bispyribac sodium; crop establishment methods; hand weeding, weed; weed management.

1. INTRODUCTION

In India, rice occupies an area of 43.79 mha with production and productivity of 116.42 mt and 2.65 t/ha,respectively [1]. Rice is reported to be one of the highly weed invaded crop and is ranked as second highest pesticide consuming crop after cotton. Rice crop suffers from various biotic and abiotic constraints. Weed competition is one of the prime yield-limiting biotic constraints in rice.Weeds compete with crops for water, light, nutrients and space. Weeds are the most competitors in their early growth stages than at later stages and hence the growth of crops was suffered and finally reduced the grain yield [2]. Weeds grow profusely in the rice field and reduce crop yields drastically normally the loss in yield range between 15-20% yet in severe cases the yield losses can be more than 50 per cent, depending upon the species and intensity of weeds. Weed flora under transplanted condition is very much diverse and consists of grasses, sedges and broad-leaved weeds causing yield reduction of rice crop up to 76 per cent [3]. The yield of transplanted rice in India is much lower than that of transplanted rice in other rice growing countries. Therefore, proper weed management is essential for satisfactory rice production in India. Herbicidal weed control has been gaining popularity in India in recent years, the main reasons are scarcity of labour during peak growing season, and also lower weeding cost by using herbicides. Most of the introduced herbicides are selective and are specified to control only one or two types of weeds. Weeds have variable growth habits and life cycles and they even vary under different cultural practices. Therefore, the use of chemicals only cannot effectively control weeds in all situations [4]. Effective weed control in transplanted rice is one of the major limitations hindering its wide spread cultivation. Manual removal of weeds is labour intensive tedious, back-breaking and does not ensure weed removal at critical stage of crop weed competition bring heavy reduction in growth and yield of the crop. Hence for transplanted rice, the chemical method of weed management is best suited as take care of weeds right from beginning of crop growth and is cost effective. Most of the herbicides recommended for rice is generally applied as pre-emergence to take care of weed during initial period. However, to have minimum competition between weeds and rice the weeds need to be kept below threshold level, especially during critical weed competition period. A new herbicide may be more effective for this purpose. Results of the study revealed that, application of Pretilachlor @ 125% of the recommended dose applied as pre-emergence under continuous flooding provided better weed control efficiency in transplanted Boro rice. But, application of Pretilachlor at recommended dose as pre-emergence under continuous flooding contributed to higher crop dry matter production leading to higher grain yield and harvest index [5]. Keeping these points in view, the present investigation was conducted to study the Effect of crop establishment methods and weed management practices on Yield and Yield attributes of Basmati rice (*Oryza sativa* L.).

2. METHODS AND MATERIALS

The field experiment was conducted to study the effect of crop establishment methods and weed management options on weed dynamics and performance of Basmati rice (*Oryza Sativa* L.)during the *kharif* season of 2019 and 2020at Crop Research Center of Sardar Vallabhbhai Patel UniversityofAgriculture &Technology, Meerut,located at latitude of 29^0 04′ North and longitude of 77^0 42′ East with an elevation of 228 meters above the mean sea level. The Meerut area lies in the heart of Western Uttar Pradesh and has sub-tropical climate(U.P.), India. The climate of this region is characterized as semi-arid and sub-tropical. The summer is very hot

and dry while winters are too cold. Moderate rainfall and wide temperature variation are the characteristic features of the semi-arid and sub-tropical climate. Generally, South-West monsoon sets in the third or fourth week of June, reaches its peaks in July and August, and continues up to September, cyclonic weather leads to few winter rains. The area receives mean annual rainfall of 845 mm, of which 80-90 per cent is received from June to September. Winter season extends from November to February, whereas frost occurs generally in the end of December and may continue up to the end of January. In general, the mean minimum temperature reaches as low as 3°C in winters, while during summer the mean maximum temperature varies from 43-45°C in the month of May.

The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction, medium in available phosphorus and potassium but low in organic carbon and available nitrogen.The experiment was laid out in split plot design with three main factors *viz*., (1) Conventional Puddled Transplanting (CPT), (2) Unpuddled Flat (UPF) and (3) Furrow Irrigated Raised Beds (FIRB) and five sub factors viz., (1) Pretilachlor @ 0.75 Kg ha^{-1} PE *fb* Bispyribac sodium @ 20 g a.i. ha^{-1} POE at 20 DAT, (2) Almix 4 g a.i. ha^{-1} + Bispyribac sodium @ 20 g a.i. ha^{-1} POE at 20 DAT, (3) Bispyribac sodium @ 25 g a.i. ha^{-1} POE at 20 DAT, (4) Two hand weedings and (5) Weedy check, the experiment was replicated by four replications.The data collected on weed density, yield and yield attributes from the experiment was subjected to statistical analysis with the procedure of split plot design (SPD) as suggested by Cochran and Cox [6]. The standard error of mean was calculated and critical difference (C.D. at 5%) was worked out for comparing the treatment means, wherever "f" test was found significant.

3. RESULTS AND DISCUSSION

3.1 Total Weed Density (No. m^{-2})

Total weed density (No. m^{-2}) at different days interval as influenced by various treatments. The total weed density increased at 60 days after transplanting and thereafter decline with the advancement in crop growth. The effect of different crop establishment methods at different observation dates was significant. The minimum total weed density was recorded under conventional puddled transplanting (E_1) followed by furrow irrigated raised bed method (E_3) while the maximum total weed density was recorded with unpuddled flat method (E_2) during both the years. At harvest the percent reduction in total weed density under conventional puddled transplanting (E_1) compared to furrow irrigated raised bed (E_3) and unpuddled flat method (E_2) was to 9.81 and 9.60, 17.44 and 14.55 during 2019 and 2020 respectively.The total weed density shows that the weed growth was slightly more as crop growth start towards development during crop season. This higher growth might be due to more favorable weather condition prevailed like rainfall, sunshine hours, and temperature. This is in accordance with finding of Singh et al. [7]. Bhardwaj et al. [8] also noted that conventionally puddled transplanted rice had significantly lower weed density (29.4%) then rest of establishment methods.

The weed management practices had significant effect on total weed density at different days interval of crop growth during both the years. The total weed density increased initially and reached maximum at 60 DAT under various weed management practices and thereafter declined at harvest. The effect of different weed management practices on total weed density was significant and two hand weedings was found most effective in reducing total weed density as compared to rest of the weed management practices. In herbicides the application of pretilachlor @ 0.75 Kg ha^{-1} *fb* Bispyribac sodium @ 20 g a.i. ha^{-1} (W_1) was found most effective in reducing the total weed density at every observation dates. At harvest, two hand weeding (W_4) and pretilachlor @ 0.75 Kg ha^{-1} *fb* Bispyribac sodium @ 20 g a.i. ha^{-1} (W_1) resulted into 58.65, 55.50 and 55.84, 54.66 percent reduction into total weed density over weedy check during 2019 and 2020 respectively.The data on total weed density as affected by different treatments indicated that in general, weed population increased up to 60 DAT, and thereafter showed decreasing trend according to their life cycle. Yadav et al. [9]also noted that maximum reduction in weed density was recorded with pre-emergence application of pretilachlor 750 g ha^{-1} *fb* post emergence application of bispyribac-Na 20 g ha^{-1} and post-emergence application of bispyribac-Na 20 g ha^{-1} at 60 DAT was most effective in controlling mixed population of the weed flora. Their effectiveness was at par with twice hand weeding. Similar findings were reported by Mishra and Singh [10] and Sangeetha et al. [11]. Higher infestation of weeds under weedy check was also reported by Singh et al. [12].

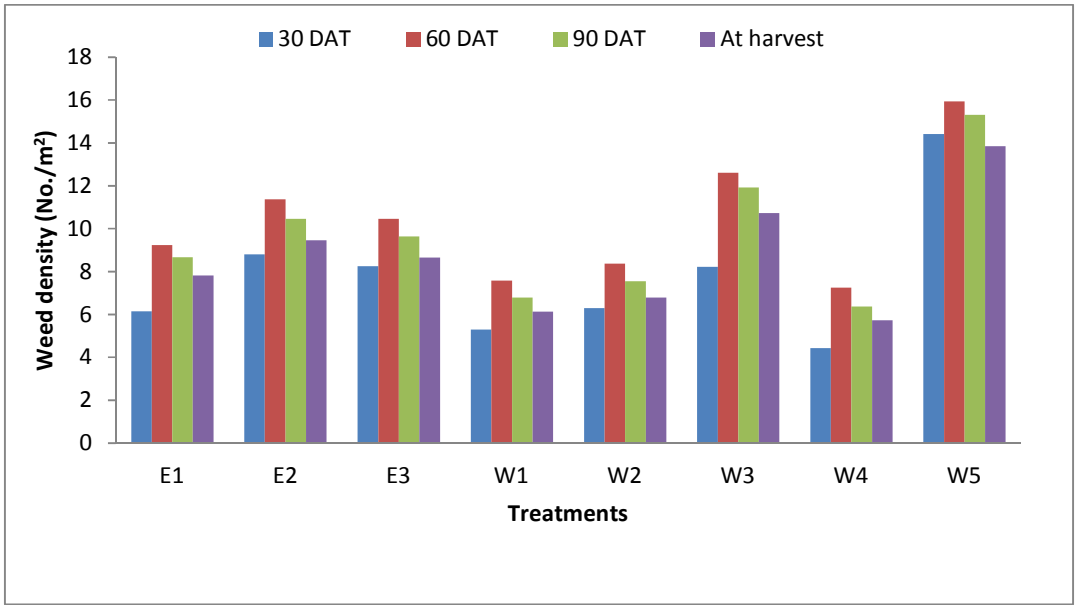

Fig. 1a. Effect of establishment methods and weed management on density of total weed density (No./m^2) at 30, 60, 90 days after transplanting and at harvest (2019)

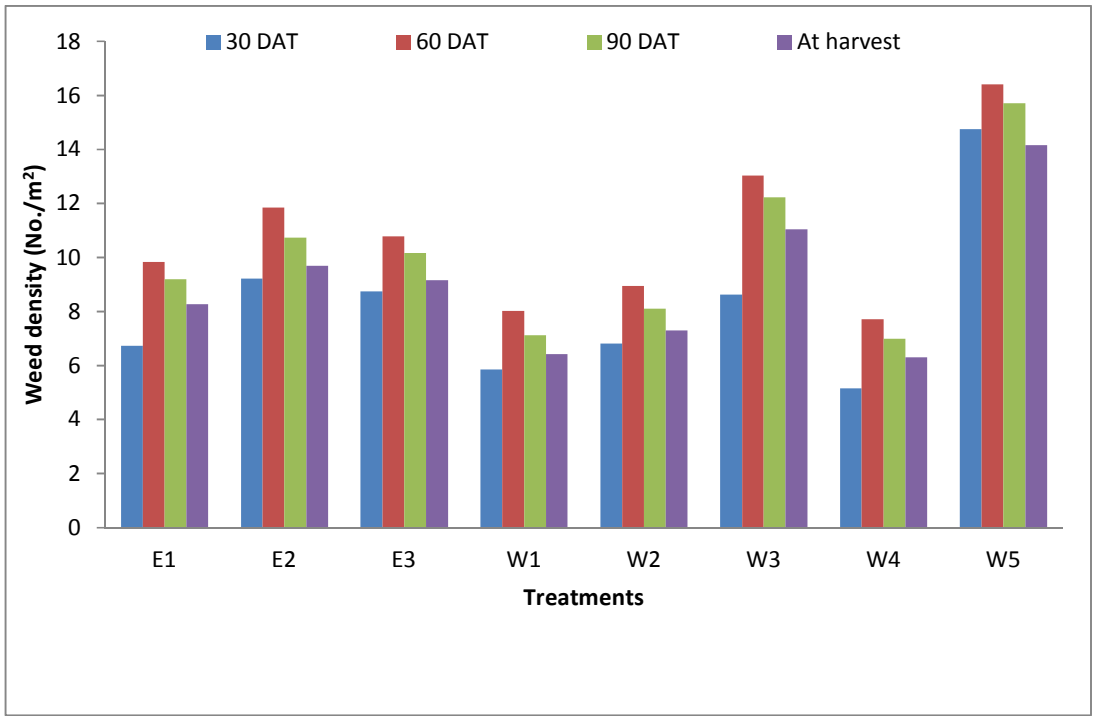

Fig. 1b. Effect of establishment methods and weed management on density of total weed density (No./m^2) at 30, 60, 90 days after transplanting and at harvest (2020)

3.2 Yield Attributes

The yield attributes *viz*; effective tillers (m^2), Panicle length (cm), no. of grain panicle^{-1} and 1000-grain weight (g)was significantly influenced by crop establishment methods and weed management practices. The highest effective tiller (182.4 and 182.6 m^2), Panicle length (24.0

and 24.5 cm), no. of grain (123.5 and 127.0) and1000-grain weight(20.43 and 20.62 g) were recorded under conventional puddled transplanting (E_1) which was significantly higher than the unpuddled flat (E_3) and at par with furrow irrigated raised bed method (E_3) in the year 2019 and 2020 respectively. Among the weed management practices the highest effective tillers (187.1 and 190.4 m^2), Panicle length (25.0 and 25.6 cm), no. of grain (124.6 and 127.0) and 1000-grain weight (20.51and 20.77 g) were obtained with pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1}(W_1) which was statistically at par with Almix 4 g a.i. ha^{-1} + Bispyribac sodium @ 20 g a.i. ha^{-1}(W_2) and two hand weedings (W_4) followed by Bispyribac sodium @ 25 g a.i. ha^{-1}(W_3) in both the years respectively. Similar findings were reported by Deepa, Jaya Kumar [6] and Javaid [13].

The yield attributes are decided by genetic makeup of the crop and variety, but the agronomic manipulation also affects them to a great extent. The reproductive growth depends on vegetative growth of plant. More vegetative growth increases the photosynthetic area and supply of photosynthetic toward sink which decides the yield attributes and ultimately the yield. The higher values of yield attributes were due to increased synthesis and translocation of metabolites for the panicle development and grain formation. Besides, thousand grain weights were also maintained because of high mobilization of photo-synthesis from source to sink. However, this is quite possible because these combinations of herbicides might have been very effective to reduce the mixed weeds density and their growth resulting in better and congenial environment favoring the rice plant to utilize nutrients, light, space luxuriantly and grew well to produce higher number of tillers m^{-2}, number of grain $panicle^{-1}$ and test weight, grain and straw yields. Similar findings were reported by Chaudhary [14].

3.3 Yields

3.3.1 Grain yield (q ha^{-1})

Grain yield was significantly influenced by crop establishment methods. The effect of different crop establishment methods on grain yield was significant. The highest grain yield (44.91 and 46.26 q ha^{-1}) recorded under conventional puddled transplanting (E_1) which was significantly higher than the unpuddled flat (E_2) (37.23 and 39.93 q ha^{-1}) and at par with furrow irrigated raised bed method (E_3) (42.97 and 44.08 q ha^{-1}) in the year 2019 and 2020 respectively. Grain yield was also significantly influenced by weed management practices. The highest grain yield (47.36 and 49.48 q ha^{-1}) was obtained with pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1} (W_1) which was statistically at par with Almix 4 g a.i. ha^{-1} + Bispyribac sodium @ 20 g a.i. ha^{-1} (W_2) and two hand weedings followed by Bispyribac sodium @ 25 g a.i. ha^{-1} (W_3) in the year 2019 and 2020 respectively. About 58.54 and 59.87% increase in grain yield due to pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1} (W_1) over weedy check during both the years. However, the lowest grain yield (27.72 and 29.62 q ha^{-1}) was obtained in weedy check (W_5). This might be due to the higher crop growth of rice in terms of foliage, large amount of photosynthesis, which act as source and helped in developing yield attributes due to low crop weed competition and finally the higher grain yield was obtained with the application of pre and post emergence herbicide, resulted in the highest grain yield.Similar findings were reported by Suganthi et al. [15]. About 41.46 and 40.13 % reduction in grain yield recorded due to weeds in both the year respectively. There was no any significant interaction between crop establishment methods and weed management practices on grain yield.Similar findings were reported by Bhomik [16] and Sangeetha [11].

3.3.2 Straw yield (q ha^{-1})

Straw yield was significantly influenced by crop establishment methods. The effect of different crop establishment methods on straw yield was significant. The highest straw yield (76.40 and 77.74 q ha^{-1}) recorded under conventional puddled transplanting (E_1) which was significantly higher than the unpuddled flat (E_2) (65.10 and 70.30 q ha^{-1}) and at par with furrow irrigated raised bed method (E_3) (73.22 and 73.82 q ha^{-1}) in the year 2019 and 2020 respectively.Straw yield was also significantly influenced by weed management practices. The highest straw yield (79.63 and 82.40 q ha^{-1}) was obtained with pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1} (W_1) which was statistically at par with Almix 4 g a.i. ha^{-1} + Bispyribac sodium @ 20 g a.i. ha^{-1} (W_2) and two hand weedings (W_4) followed by Bispyribac sodium @ 25 g a.i. ha^{-1} (W_3) in the year 2019 and 2020 respectively. About 79.12 and 81.78% increase in straw yield due to pretilachlor @ 0.75

Kg ha^{-1} *fb* Bispyribac sodium @ 20 g a.i. ha^{-1} (W_1) over weedy check (W_5) during both the years. However, the lowest straw yield (53.20 and 55.38 q ha^{-1}) was obtained in weedy check (W_5). About 33.19 and 32.79 % reduction in straw yield recorded due to weeds in both the year respectively. There was no any significant interaction between crop establishment methods

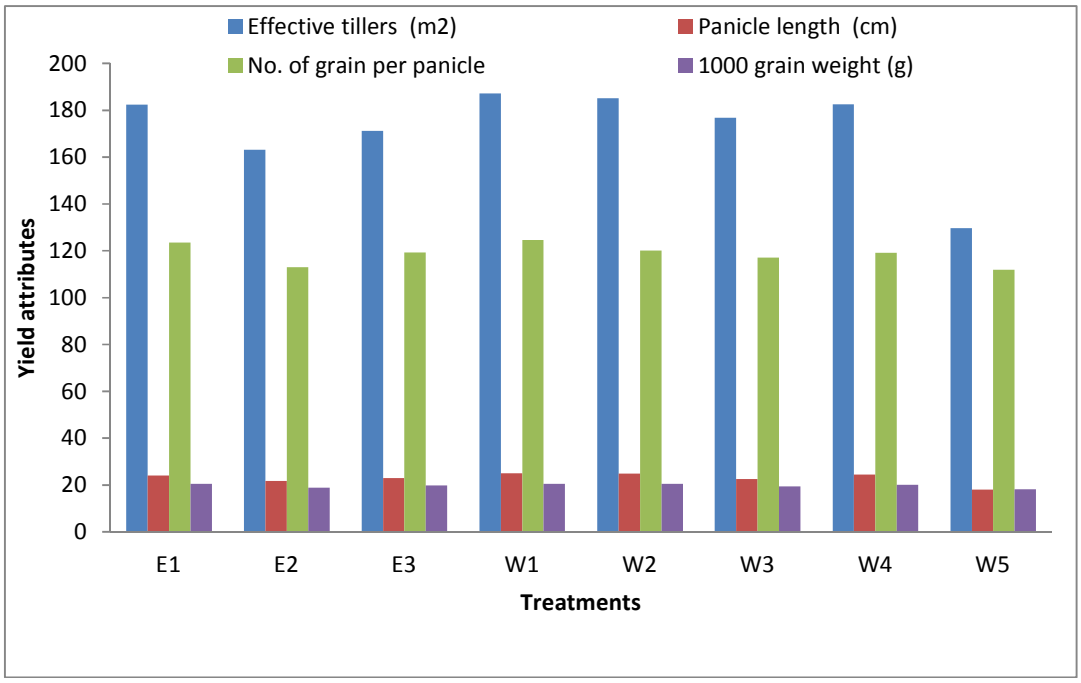

Fig. 2a. Effect of establishment methods and weed management on yield attributes of basmati rice (2019)

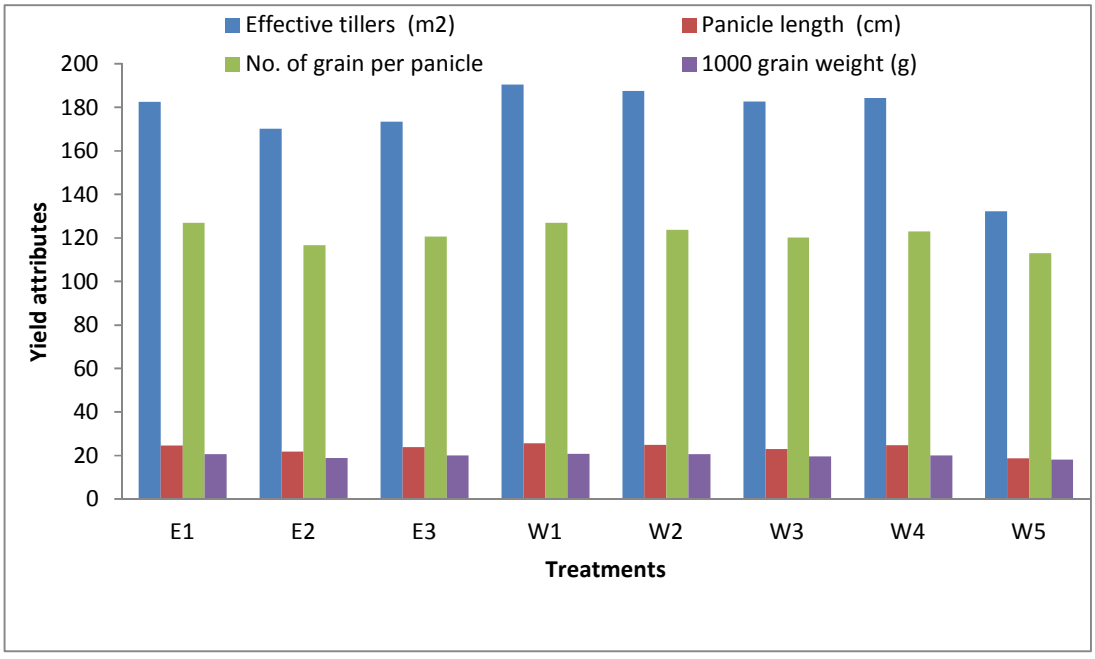

Fig. 2b. Effect of establishment methods and weed management on yield attributes of basmati rice (2020)

and weed management practices on straw yield. Higher straw yield was due to more accumulation of dry matter (g m^{-2})along with the highest plant height and number of tillers m^{-2}. The application of Pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1} was recorded straw yield (79.63 & 82.40 q ha^{-1}) which was (49.23%) higher as compared to weedy check plots. similar findings were reported by Prasad et al. [17] and Sabha Jeet et al. [18].

3.3.3 Biological Yield (q ha^{-1})

Biological yield was significantly influenced by crop establishment methods. The effect of different crop establishment methods on biological yield was significant.The highest biological yield (121.31 and 124.00 q ha^{-1}) recorded under conventional puddled transplanting (E_1) which was significantly higher than the unpuddled flat (E_2) (102.33 and 110.23 q ha^{-1}) and at par with furrow irrigated raised bed method (E_3) (116.19 and 117.90 q ha^{-1}) in the year 2019 and 2020 respectively.Biological yield was also significantly influenced by weed management practices. The highest biological yield (126.99 and 131.88 q ha^{-1}) was obtained with pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1} (W_1) which was statistically at par with Almix 4 g a.i. ha^{-1} + Bispyribac sodium @ 20 g a.i. ha^{-1} (W_2) and two hand weedings (W_4) followed by Bispyribac sodium @ 25 g a.i. ha^{-1} (W_3) in the year 2019 and 2020 respectively. About 64.32 and 64.05% increase in biological yield due to pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1} over weedy check (W_5) during both the years. However the lowest biological yield (80.92 and 85.00 q ha^{-1}) was obtained in weedy check (W_5). About 56.93 and 55.15 % reduction in biological yield recorded due to weeds in both the years, respectively. There was no any significant interaction between crop establishment methods and weed management practices on biological yield. Similar findings were also reported by Suganthi [19].

3.3.4 Harvest index (%)

Harvest index was non significantly influenced by crop establishment methods. The highest harvest index (36.90 and 37.17 %) recorded under conventional puddled transplanting (E_1) which was higher than the furrow irrigated raised bed method (E_2) and unpuddled flat (E_3) in the year 2019-20 and 2020-21 respectively. Harvest index was significantly influenced by weed

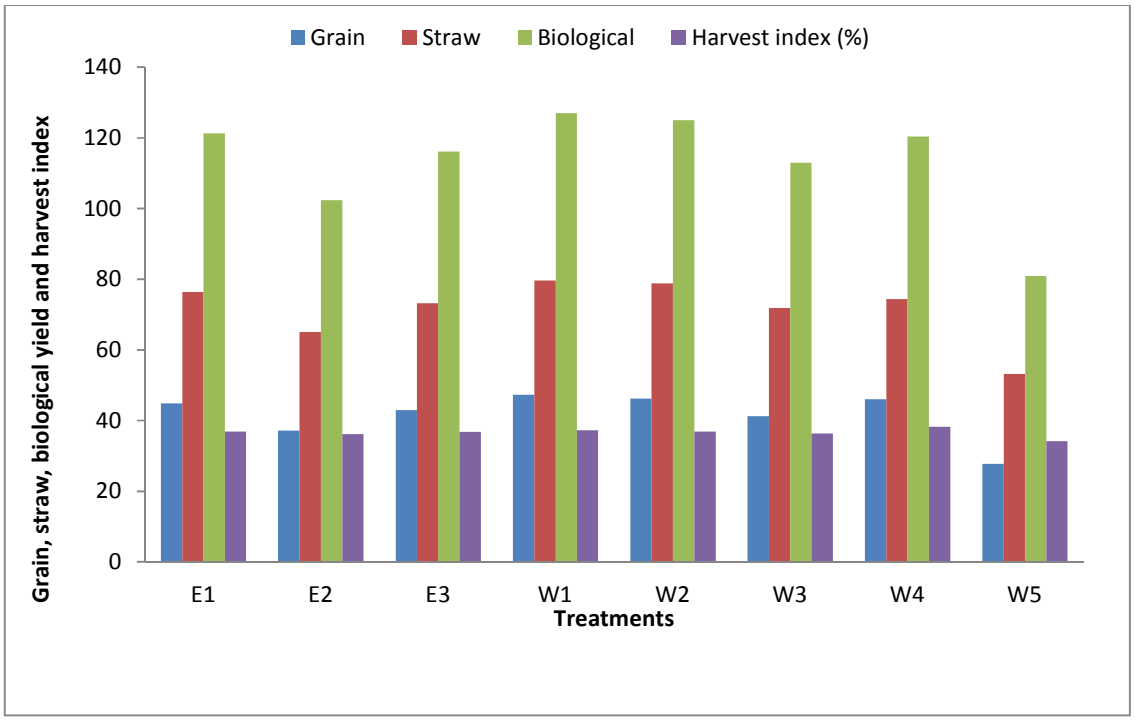

Fig. 3a. Effect of establishment methods and weed management on grain, straw, biological yield and harvest index of basmati rice (2019)

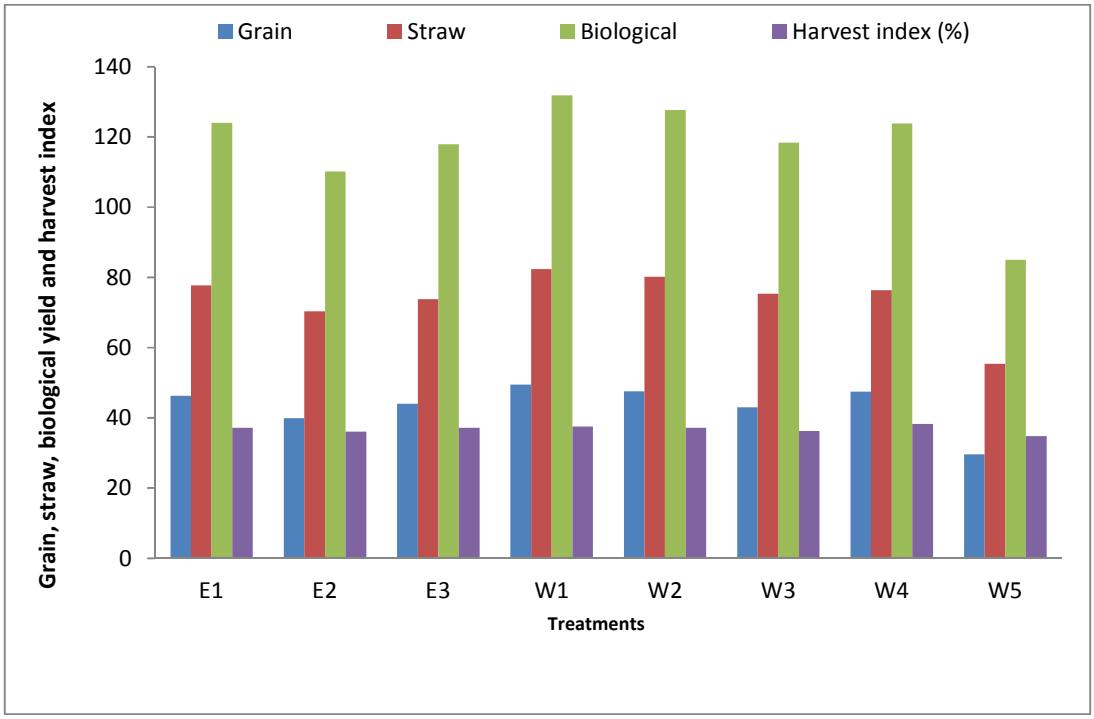

Fig. 3b. Effect of establishment methods and weed management on grain, straw, biological yield and harvest index of Basmati rice (2020)

management practices. The highest harvest index (38.23 and 38.29 %) was obtained with two hand weedings(W_4) which was statistically at par with pretilachlor @ 0.75 Kg ha^{-1}*fb* Bispyribac sodium @ 20 g a.i. ha^{-1}(W_1) and Almix 4 g a.i. ha^{-1} + Bispyribac sodium @ 20 g a.i. ha^{-1}(W_2) and followed by Bispyribac sodium @ 25 g a.i. ha^{-1}(W_3)in the year 2019-20 and 2020-21 respectively. However, the lowest harvest index (34.21 and 34.81 %) was obtained in weedy check. There was no any significant interaction effect among crop establishment methods and weed management practices.

4. CONCLUSION

The data recorded from two-year field experiment revealed that basmati rice crop gave the highest yield under conventional puddled transplanted condition with the application of Pretilachlor @ 0.75 Kg ha^{-1} PE *fb* Bispyribac sodium @ 20g a.i. ha^{-1} POE at 20 DAT. Therefore, it can be concluded thatpuddled transplantation in rice might be the best option to get higher yield and for weed control, application of Pretilachlor @ 0.75 Kg ha^{-1} PE *fb* Bispyribac sodium @ 20 g a.i. ha^{-1} POE at 20 DAT may be done to get higher yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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