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RESEARCH ARTICLE

Comparative analysis of pre- and post-emergence herbicides on weed suppression and yield enhancement in pearl millet (*Pennisetum glaucum* L.)

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Abstract

Pearl millet is the most widely grown drought-tolerant coarse nutricereal grown in the harshest semi-arid regions. Its cultivation is declining due to low productivity and susceptibility to biotic and abiotic stresses because its early growth and wide spacing make it vulnerable to weeds. This research aims to find the effect of different weed management practices in pearl millet on its growth and productivity. It was conducted at the Eastern Block farm, Tamil Nadu Agricultural University (TNAU), in the summer 2024 where eight treatments were plotted in a randomized block design (RBD) with three replications and treatment consisting of seven different combinations of weed management practices (T_1 to T_7) along with a control treatment (T_8) having no weed control practices. Results show that lower weed density, weed dry matter production and higher grain yield was observed in hand weeding twice at 15 and 25 days after sowing (DAS) which is significantly on par with the pre-emergence application of Atrazine 50 % WP at 0.25 kg a.i. ha^{-1} fb hand weeding at 25 DAS. Higher N, P and K uptake at harvest was observed with same trend. Grain yield showed a significant negative and positive correlation with weed biomass and dry matter production respectively. The results of the field experiment concluded that hand-weeding twice at 15 DAS and 25 DAS has the same effect as the pre-emergence application of Atrazine 50 % WP at 0.25 kg a.i/ha combined with one hand weeding at 25 DAS effectively controls weeds and maximizes growth and productivity under rainfed conditions.

Keywords: efficacy; hand weeding; herbicides; intergrated weed management; mulching

Introduction

As the world celebrates the International Year of Millets, the significance of the resilient, nutrient-rich millets in global food security and sustainable agriculture have never been more apparent. Among these millet, Pearl millet (*Pennisetum glaucum*) one of the most widely cultivated and drought-tolerant millets holds immense potential to address the challenges of climate change, nutritional deficiency and food scarcity, particularly in arid and semi-arid regions. It is a vital nutricereal crop cultivated on approximately 30-40 million hectares in arid and semi-arid regions of Asia and Africa (1). The crop nutritional profile is impressive, containing higher levels of energy, dietary fiber, balanced proteins, minerals, vitamins and antioxidants, making it a primary source of calories for millions in developing countries. Pearl millet accounts for about 50 % of the total global production of millets as India is the largest single producer of the crop, both in terms of area (43.78 lakh hectares) and production (48.12 lakh tonnes) with an average productivity of Villupuram, Thoothukudi, Madurai, Theni and Dharmapuri districts with an area of 5.60 lakh ha with a production of 5.90 lakh tonnes and productivity of 1054 kg/ha (2). However, compared to its potential yield, productivity in India is low. One of the most important problems restricting the productivity of Pearl millet is weed infestation which can significantly reduce yield, with losses ranging from 35-90 % (3) and potentially exceeding 72 % (4). The critical period for weed control (CPWC) in pearl millet is essential for optimizing yield, particularly due to its susceptibility to weed competition during early growth stages. The first 20-30 days after sowing is the most critical period for weed control affecting tillering and panicle formation (5, 6).

Common methods for weed control in pearl millet cultivation are inter-culturing and hand weeding. Hand weeding is essential in the early stages of pearl millet, as it helps manage aggressive weeds like *Cyperus spp.* and *Digitaria horizontalis*, which can severely impact yield (7). Mulching is an effective strategy for controlling weeds in pearl

millet cultivation, enhancing both crop yield and soil health. Mulching significantly reduces weed density and dry weight. For instance, paddy straw and black polythene mulches have shown effective weed control compared to unweeded plots (8). Pearl millet straw has demonstrated allelopathic properties, effectively suppressing the emergence of common weeds like *Euphorbia heterophylla* (9). While these techniques are effective, they have notable limitations such as labour scarcity during peak farming periods and the high cost (10). Over time, these challenges highlight the need for herbicides as a more efficient and cost-effective alternative to traditional weed management practices. Pre-emergence herbicides typically offer effective weed control for over a few days after application as its efficacy depends on moisture content, thereby weeds can pose a significant threat to the crop. In some cases, due to unavoidable circumstances, the application of pre-emergence herbicides may be delayed or missed, making manual weed control increasingly challenging. In such scenarios, an integrated approach combining pre-emergence with mechanical weeding or early post-emergence herbicides offers a viable solution for managing subsequent weed infestation (11). But the application of herbicides alone is not a feasible choice from a sustainable point of view. Thus, the integration of different approaches to weed control may be brought together to reduce the weed infestation below economic threshold level (12). While hand weeding is common, integrating it with herbicides and other cultural practices is recommended to enhance weed control efficiency (13, 14). This study aims to evaluate the effect of integration of pre and post emergence application of herbicides along with cultural methods on weed control of pearl millet. By analysing parameters such as weed density, weed dry weight, crop growth and overall yield, the re-search seeks to highlights the potential benefits and limitations of drone technology in modern rice cultivation.

Material and Methods

The field experiment was carried out at the Eastern Block farm (Tamil Nadu Agricultural University), Coimbatore Tamil Nadu, India at 11.01° N, 76.93°E and at an altitude of 426.8 m above mean sea level during cropping period of February to April, 2024. The soil of the experiment site was categorized as sandy clay loam with slightly alkaline exhibiting pH 7.72 and high organic matter (1.66 %) and low available N (193 kg/ha) and medium in available P_2O_5 (18.6 kg/ha) and high available K_2O (705 kg/ha). The average minimum atmospheric temperature for the summer season of the cropping year recorded 24.4 °C and that of maximum temperature 34.0 °C. In the cropping season, the mean relative humidity was 54 %. The cropping period received precipitation of about 34.9 mm and the average wind speed were 5.2 km hr^{1} (Fig. 1).

Eight treatments were implemented in total, consisting of seven different combinations of weed management practices (T_1 to T_7) along with a control treatment (T8) having no weed control practices was included. The treatment details are as follow:

T_1 : Pre-emergence application of Atrazine 50 % WP @ 0.25kg a.i. ha^{-1} on 3 DAS *fb* hand weeding on 25 DAS

T_2 : Pre-emergence application of Pendimethalin 38.7 % CS @ 1kg a.i. ha^{-1} on 3 DAS *fb* hand weeding on 25 DAS

T_3 : Post-emergence application of Tembotrione 34.4 % SC @ .01kg a.i. ha^{-1} on 4- 5 leaf stage

T_4 : Pre-emergence application of Atrazine 50 % WP @ 0.25 kg a.i. ha^{-1}on 3 DAS *fb* post-emergence application of Tembotrione 34.4 % SC @ 0.01 kg a.i. ha^{-1} on 4- 5 leaf stage

T_5 : Pre-emergent application of Pendimethalin 38.7 % CS @ 1kg a.i. ha^{-1} on 3 DAS *fb* post-emergence application of Tembotrione 34.4 % SC @ 0.01kg a.i. ha^{-1} on 4- 5 leaf stage,

T_6 : Mulching @ 5 tonne/ha

T_7 : Hand weeding twice at 15 DAS and 25 DAS

T_8 : Weedy check (Un weeded control)

The Randomized complete block design was used to arrange three replica plots for each treatment of 30 m^2 (5x6 m) in the fields. Before raising the crop, the green manure, Dhaincha (*Sesbania bispinosa*) was raised and incorporated into the field at the time of 50 % flowering. The pearl millet variety Co H 10 seeds were sown at a spacing of 45 × 15 cm and irrigated as required depending on the moisture status of the soil and requirement of plants, N P K were provided at 80:40:40 ratio in the form of Urea, SSP (Single Super Phosphate) and MOP (Muriate of Potash) where P, K and half of N dose was applied basally and remaining half of N dose was applied in two equal split doses at 30 DAS and 45 DAS. All crop management practices were performed as per the recommendation of crop production guide 2022, TNAU.

The observations on species-wise weed flora diversity were recorded in experimental field in all plots at 15, 30, 45 DAS and at harvest. The data on weed population, weed density, weed dry weight, weed control efficiency (15) and weed index (16) were recorded at 15, 30, 45 DAS of crop and expressed in nos m^{-2} and kg/ha respectively. The equation for weed control efficiency and weed index is given below.

$$WCE(\%) = \frac{\text{Weed dry weight in weedy check} - \text{Weed dry weight in respective treatment}}{\text{Weed dry weight in weedy check}} \quad \text{Eqn. 1}$$

$$WI(\%) = \frac{\text{Yield from weed free plot} - \text{Yield from respective treatment plot}}{\text{Yield from weed free plot}} \quad \text{Eqn. 2}$$

Observation on plant height, dry matter accumulation, grain yield and stover yield were recorded periodically during the crop growth cycle as per the standard procedure suggested by (17). Five plants along with roots per plot were pulled out at random at 15, 30, 45 DAS of the crop to measure the dry matter production. The sample plants were shade-dried and oven-dried at 70 ± 50 °C for 48 hr until a constant weight was reached. Dry matter production was worked out by recording dry weight of the samples and expressed in kg/ha.

Following threshing, a composite grain sample from each plot was obtained, cleaned, sun dried and later the total grains were weighed to determine the grain yield. The moisture content of grains during harvest was 20 %. Yield parameter like length of ear head, girth of ear head and 1000 grain weight (g), number of effective tillers plant^{-1}were recorded. Microbial population count of bacteria, fungi and actinomycetes was done at initial 15, 30 and 45 DAS and was determined by the serial dilution and pour plating method. Bacterial population was estimated by nutrient agar method, fungal population was cultured on rose bengal agar, actinomycetes population was enumerated using Kenknight agar culture media. After incubation period, the colonies were counted and the number of viable bacteria, fungi and actinobacteria (expressed as colony forming units (cfu) per gram dry weight of soil was estimated by considering the serial dilutions.

Data showing wide variation and having the value zero in weed density and dry weight, were subjected to square root transformation [$\sqrt{(x + 0.5)}$] before statistical analysis to normalize their distribution. Statistical significance was tested using the F-test, with a critical difference (CD) at a 0.05 probability level (18). The correlation analysis int the form of weed dry weight, dry matter production, nutrient uptake and grain yield was evaluated using Pearson linear correlation analysis (R Studio Version: 2024.04.2+764).

Results and Discussion

Effect of weed control practices on weed flora and weed parameter

In field experiment,broad leaved weeds such as *Trianthema portulacastrum, Parthenium hysterophorous, Amaranthus viridis, Digera arvensis*, *Datura stramonium* grasses such as *Cynodon dactylon, Dactyloctenium aegyptium* and sedges like *Cyperus rotundus* were observed. Out of which *Trianthema portulacastrum*, *Datura stramonium* and *Cynodon dacytlon* were found to be predominant during the crop-growing period. The dominance of *Trianthema portulacastrum* was also observed in pearl millet cultivation in South India (19). Weed control treatments showed significant difference in weed density and weed dry matter production at 15, 30 and 45 DAS (Days after sowing). At 15 DAS, among the treatments, Atrazine 50 % WP@ 0.25 kg a.i./ha *fb* post-emergence application of Tembotrione 34.4 % SC @ .01 kg a.i. ha^{-1}on 4-5 leaf stage recorded lower total weed density (16.52 m^{-2}) followed by pre-emergence application of Atrazine 50 % WP @ 0.25 kg a.i.ha^{-1} *fb* hand weeding on 25 DAS with total weed density (21.3 m^{-2}). In contrary to previous observation, the lowest weed population/m^2 was found in the treatment with hand weeding twice at 15 DAS and 25 DAS (T_7) having values of 12.81, 17.8 at 30 and 45 DAS respectively followed by pre-emergence application of Atrazine 50 % WP @ 0.25 kg a.i.ha^{-1} *fb* hand weeding on 25 DAS (Table 1). It might be due to combination of herbicide followed by hand weeding drastically reduced weed density leading to reduced built up of soil weed seed bank (20).

Weed dry matter is the most important parameter to measure competition by weeds rather than weed density since, it precisely measures the quantity of growth-related factors utilized by weeds. The minimal weed dry weight of 2.69 g m^{-2} at 15 days after sowing (DAS) was recorded following the pre-emergent application of Atrazine 50 % WP at a dosage of 0.25 kg a.i. ha^{-1} *fb* hand weeding at 25 DAS (T_1). This outcome is statistically comparable to the results obtained from the application of Atrazine 50 % WP at 0.25 kg a.i. ha^{-1} *fb* post-emergence application of Tembotrione 34.4 % SC at a concentration of 0.1 kg a.i. ha^{-1} at the 4-5 leaf stage, which yielded a weed dry weight of 3.36 g m^{-2} (T_4). At 30 DAS, the most minimal production of weed dry matter was documented in response to T_7 - hand weeding twice at 15 DAS and 25 DAS, resulting in a weight of 6.82 g m^{-2}, followed by the pre-emergence application of Atrazine 50 % WP at 0.25 kg a.i. ha^{-1} accompanied by hand weeding at 25 DAS, which recorded a total weed density of 10.72 g m^{-2} (T_1). A similar pattern was noted at 45 DAS, with the lowest weed dry weights recorded at 18.12 g m^{-2} and 34.46 g m^{-2} respectively, attributed to the treatment T_7 involving hand weeding twice at 15 DAS and 25 DAS. Over the entire cropping duration, the weedy check (T_8) treatment exhibited elevated levels of weed density and accumulated weed dry weight, a trend that persisted throughout the critical stages (Table 1). Earlier studies have shown that hand weeding done twice at certain interval after sowing considerably diminishes both weed

Table 1. Effect of different weed control practices on total weed density, dry weight of pearl millet @ 15, 30 and 45 DAS

Treatment	Total weed density (Nos. m^{-2})			Weed dry weight (g ha^{-1})		
	15 DAS	30 DAS	45 DAS	15 DAS	30DAS	45 DAS
T_1	4.66 (21.3)	4.74 (22.02)	5.03 (29.58)	1.79 (2.69)	3.34 (10.72)	5.32 (27.77)
T_2	4.79 (22.53)	5.70 (31.99)	5.86 (45.23)	2.39 (5.23)	4.78 (22.36)	5.97 (35.14)
T_3	7.60 (57.42)	7.68 (58.43)	6.74 (87.99)	3.99 (15.45)	6.52 (42.14)	7.21 (51.46)
T_4	4.12 (16.52)	5.08 (25.39)	5.39 (33.96)	1.96 (3.36)	3.73 (13.45)	5.54 (30.14)
T_5	5.10 (25.53)	6.39 (40.45)	6.35 (58.15)	2.59 (6.19)	5.35 (28.14)	6.29 (39.14)
T_6	7.95 (59.88)	8.02 (63.93)	7.29 (79.27)	3.95 (15.1)	7.11 (50.15)	7.69 (58.76)
T_7	7.88 (61.56)	3.89 (12.81)	4.14 (17.8)	4.09 (16.31)	2.69 (6.82)	4.31 (18.12)
T_8	8.28 (68.04)	10.15 (103.20)	8.38 (114.03)	4.25 (17.64)	9.66 (92.9)	11.11 (123.23)
SE (d)	0.24	0.26	0.31	0.13	0.24	0.28
CD (P=0.05)	0.51	0.57	0.66	0.29	0.51	0.59

density and dry weight in maize, thereby enhancing weed control efficacy (21). Prolonged chemical control measures and hand weeding demonstrate analogous impacts on weed community dynamics, effectively sustaining relatively low infestation levels (22). Among the various weed management strategies employed at 15 DAS, the highest recorded weed control efficiency (84.75 %) was attained through the pre-emergent application of Atrazine 50 % WP at 0.250 kg a.i. ha^{-1} *fb* one hand weeding at 25 DAS (T_2) closely followed by the T_4-pre-emergent application of Atrazine 50 % WP at 0.25 kg a.i. ha^{-1} *fb* post-emergent application of Tembotrione 34.4 % SC at 0.1 kg a.i. ha^{-1} during the 4-5 leaf stage, which yielded an efficiency of 80.95 %. Because at first 15 DAS, no treatment other than pre emergent application of herbicide like Atrazine and Pendimethalin cause severe reduction in weed infestation. Conversely, the lowest weed control efficiency was recorded in the unweeded control treatment (7.54 %). In subsequent growth stages, hand weeding twice at 15 and 25 DAS (T_7) exhibited the highest weed control efficiencies, measuring 92.66 % and 85.29 % at 30, 45 DAS, respectively (Fig. 1). This was succeeded by the pre-emergent application of Atrazine 50 % WP at 0.250 kg a.i. ha^{-1} combined with one hand weeding at 25 DAS (T_8), which demonstrated efficiencies of 88.46 % and 77.46 % at 30 and 45 DAS, respectively, along with the combination of pre-emergent Atrazine application with post-emergent Tembotrione application (T_4), which yielded weed control efficiencies of 85.52 %, 75.54 % and 59.93 % at 30, 45 DAS respectively. The unweeded control (T_8) consistently exhibited the lowest weed control efficiency throughout all growth stages (Fig. 1). Research has shown that the pre-emergent application of Atrazine coupled with hand weeding at 30 DAS results in the highest weed control efficiency observed in maize (23). Among all treatments, the highest weed index was observed in the unweeded control (T_8), with 50.29 %. The lowest weed index (3.20 %) was recorded with the pre-emergence application of Atrazine 50 % WP at 0.250 kg a.i. ha^{-1} combined with one hand weeding at 25 DAS(T_1), followed by the pre-emergence application of Atrazine 50 % WP at 0.25 kg a.i. ha^{-1} *fb* post-emergence application of Tembotrione 34.4 % SC at 0.1 kg a.i. ha^{-1} at the 4-5 leaf stage (9.54 %) (T_4) (Fig. 2). In short, these results shows that other methods like mulching also showed potential but were less effective than atrazine alone in terms of immediate weed suppression and intregration of herbicide with cultural methods cause effective weed control is equally effective as manual weeding (8).

Effect of weed control practices on growth parameter of pearl millet

Various methods including hand weeding and herbicide application, have been shown to increase crop growth parameters and yield components (24). At 15 DAS, taller plants were recorded in pre emergent application of Atrazine 50 % WP @ 0.25 kg a.i.ha^{-1} + Post emergence application of Tembotrione 34.4 % SC @ 100 g a.i. ha^{-1}on 4-5 leaf stage (24.66cm) (T_4). At 30 DAS, the tallest plants (88.36 cm) were observed with hand weeding at 15 and 25 DAS (T_7), closely followed by T_1i.e, application of Atrazine 50 % WP at 0.25 kg a.i. ha^{-1} *fb* one hand weeding at 25 DAS (84.38 cm). This trend continued at 45 DAS, with maximum heights of 149.85 cm and 132.85 cm for the respective treatments. The unweeded control (T_8) consistently had the shortest plants, with heights of 14.22 cm, 58.39 cm and 98.68 cm at 15, 30 and 45 DAS respectively. This might be due to maximum competition with weeds, which creates an unfavorable environment for effective utilization of nutrients, moisture and solar radiation resulting in lower photosynthesis rate and dry matter production (25). In addition to plant height, higher dry matter production of 0.14 kg ha^{-1} at 15 DAS is observed in pre-emergence application of Atrazine 50 % WP @ 0.25 kg a.i.ha^{-1} *fb* post-emergence application of Tembotrione 34.4 % SC @.01 kg a.i. ha^{-1}on 4-5 leaf stage (T_4) followed by pre-emergence application of Atrazine 50 % WP @ 0.25 kg ai ha^{-1} *fb* hand weeding on 25 DAS (T_1) (0.12 kg ha^{-1}) and at 30 DAS,

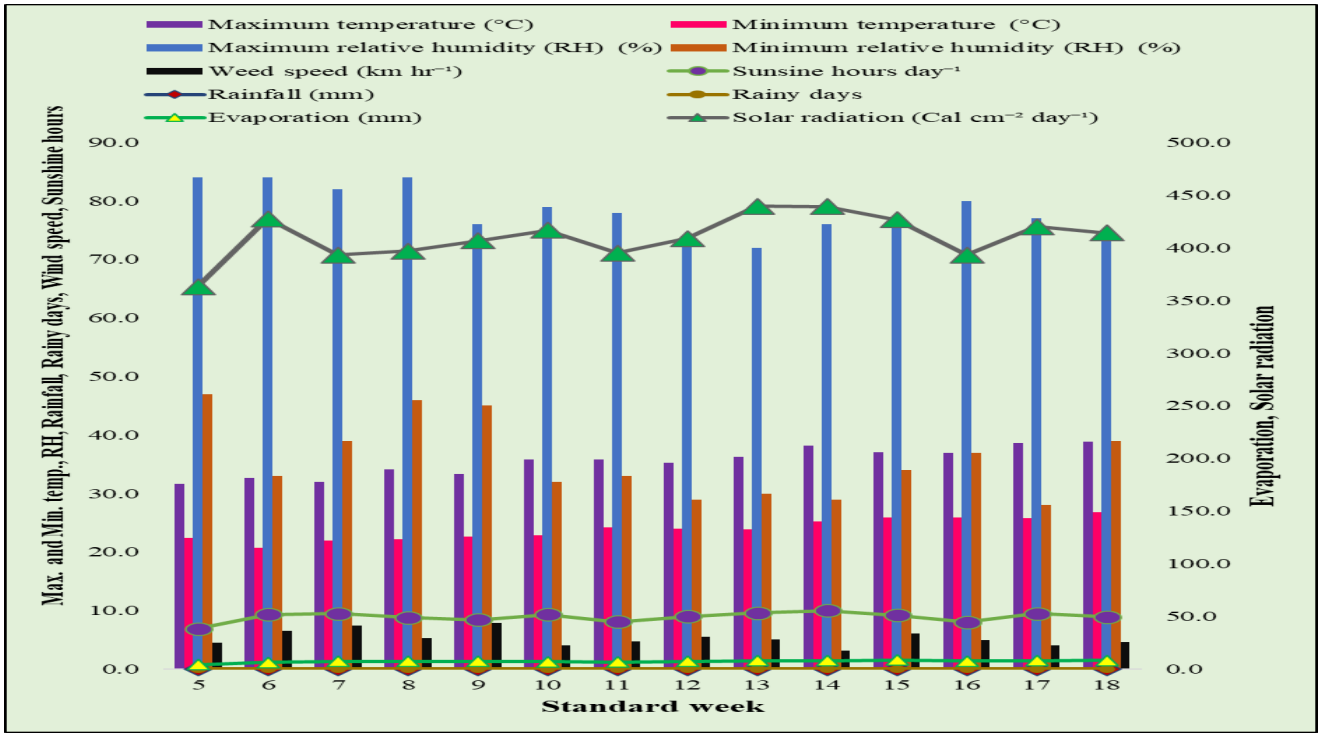


Fig. 1. Weather parameters prevailed during the cropping period of pearl millet Hybrid CoH 10 during Jan-April, 2024.

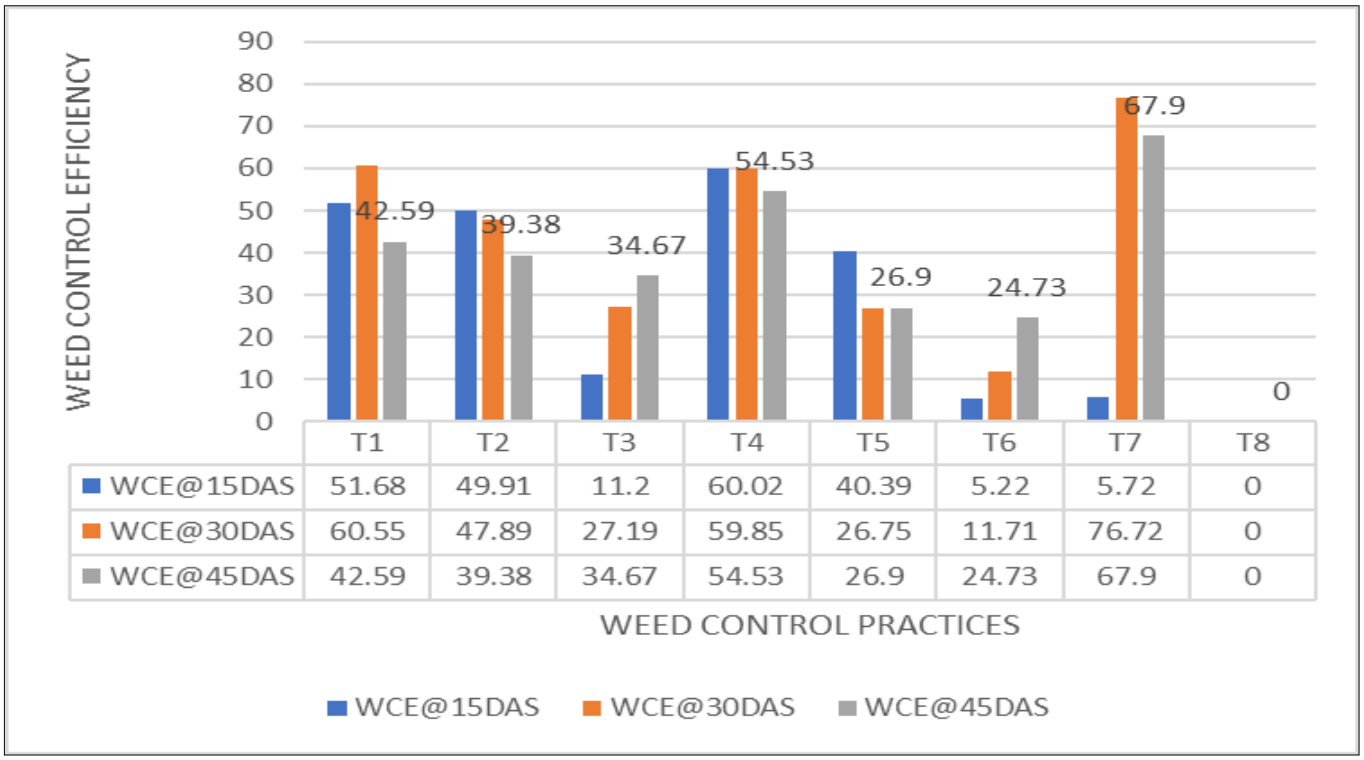


Fig. 2. Effect of different weed management practices on the weed control efficiency (%) at 15 DAS, 30 DAS, 45 DAS and at harvest.

T_1-Pre emergence application of Atrazine 50 % WP @ 0.25 kg g a.i. ha^{-1} on 3 DAS + one hand weeding on 25 DAS, T_2-Pre emergence application of Pendimethalin 38.7 % CS @ 1 kg a.i. ha^{-1} on 3 DAS + one hand weeding on 25 DAS, T_3-Post emergence application of Tembotrione 34.4 % SC @ 0.01 kg a.i ha^{-1} on 4- 5 leaf stage, T_4- Pre emergent application of Atrazine 50 % WP @ 0.25 kg a.i ha^{-1} on 3 DAS + Post emergence application of Tembotrione 34.4 % SC @ 0.01 kg a.i. ha^{-1} on 4- 5 leaf stage, T_5- Pre emergent application of Pendimethalin 38.7 % CS @ 1 kg a.i. ha^{-1} on 3 DAS + Post emergence application of Tembotrione 34.4 % SC @ 0.01 kg a.i ha^{-1} on 4- 5 leaf stage, T_6-Mulching @ 5 tonne/ha,T_7-Hand Weeding twice at 15 DAS and 25 DAS, T_8-Weedy check (Unweeded control

the highest dry matter production of 650 kg ha^{-1} was recorded with hand weeding at 15 and 25 DAS (T_7), followed by pre-emergent application of Atrazine 50 % WP at 0.250 kg a.i. ha^{-1} *fb* one hand weeding at 25 DAS (618 kg/ha). At 45 DAS also, hand weeding at 15 and 25 DAS continued to lead with 6325 kg/ha closely followed by the combination of pre-emergence application of Atrazine and hand weeding at 25 DAS with 6162 kg ha^{-1}.The next best treatment after T_7 and T_1 is T_2 ie., pre -emergence application of Pendimethalin 38.7 % CS @ 1 kg a.i. ha^{-1} on 3 DAS + one hand weeding on 25 DAS (Table 2). Similarly studies show that the combination of manual weeding and herbicide application not only reduces competition from weeds but also optimizes resource utilization, enhancing photosynthesis and growth (26).

The reduction of DMP to 29.3, 23.6 % at 30 DAS, 45 DAS was recorded with the weedy check (T_8) compared to the hand weeding at 15 and 25 DAS (T_7). It is plausible that the reduced weed dry biomass in treatment T_7 correlates with the increased dry matter production (DMP) of the plant as low competition from weeds facilitates greater plant height and cause greater dry matter production. In the case of physiological parameters, application of post-emergence herbicide like Tembotrione along with pre-emergent herbicide causes stunting and phytotoxicity in crop stand causing T_4 having lesser value compare to treatment involving pre-emergence application of Pendimethalin 38.7 % CS @ 1 kg a.i. ha^{-1} on 3 DAS *fb* one hand weeding on 25 DAS (T_2) while pre- and post-emergent applications reduced plant stand as application of herbicide will cause stunting of crop (27).

Table 2. Effect of different weed control practices on plant height, dry matter production and yield of pearl millet

Treatments	Plant height (cm)			Dry matter production (kg/ha)			Grain yield (kg/ha)	Stover yield (kg/ha)
	15 DAS	30 DAS	45 DAS	15 DAS	30 DAS	45 DAS		
T_1	22.88	84.38	132.8	38.00	618	6162	3135	5684
T_2	15.04	78.89	124.3	35.00	605	6104	2240	5386
T_3	14.22	62.78	109.9	29.00	506	5065	1914	5155
T_4	24.66	71.69	115.8	39.00	597	5819	2930	5597
T_5	16.66	64.97	114.8	37.00	527	5330	2038	5206
T_6	14.72	63.46	110.9	31.00	518	5137	1773	4718
T_7	14.33	88.36	149.8	30.11	650	6325	3229	5788
T_8	14.22	58.39	98.68	27.42	459	4826	1610	3570
SE (d)	1.71	3.56	5.91	2.05	34.63	369.1	100.5	251.8
CD (P=0.05)	3.80	7.63	12.67	4.40	74.26	791.7	215.7	540.1

Effect of weed control practices in yield of crop

Studies asserted that integrated weed management strategies that incorporate pre-emergence herbicides alongside hand weeding significantly enhanced overall yield and nutrient assimilation in wheat which was observed in this experiment also (28). Grain yield was significantly higher with hand weeding at 15 and 25 DAS (3239 kg ha^{-1}) (T_7) which is significantly on par with T_1 the pre-emergence application of Atrazine 50 % WP at 0.25 kg a.i. ha^{-1} *fb* one hand weeding at 25 DAS (3135 kg/ha). The lowest yield of 1610 kg/ha and 1773 kg/ha were recorded in the control (T_8) and mulching @ 20 DAS (T_6) respectively. Stover yield followed a similar pattern, with hand weeding at 15 and 25 DAS producing the highest yield (T_7) (5788 kg/ha), on par with the pre-emergence application of Atrazine 50 % WP at 0.25 kg a.i. ha^{-1} *fb* one hand weeding at 25 DAS (5684 kg/ha) (T_1), while the lowest stover yield was observed in the control (3570 kg/ha). Similar results have been identified the case of weed management studies in chickpea conducted in Parbhani, where hand weeding twice resulted in the highest plant height, plant spread, branches, root nodules and dry matter followed by other herbicidal treatment (29).

Regression and correlation analysis of weed, growth and yield attributes of Pearl millet

The correlations between these parameters (e.g., 0.62 between weed dry weight at 15 DAS and 30 DAS) are positive and statistically significant. It shows inverse relationships with weed dry weight (e.g., b = -0.85 for weed dry weight at 15 DAS and DMP at 15 DAS), indicating that dry matter production tends to decrease as weed dry weight increases. It also reflect the relationship between nutrient uptake by plants and other variables showing negative correlations (e.g., -0.31 between N uptake by plant and weed dry weight at 15 DAS) suggest that higher weed dry weight may reduce nutrient uptake by plants (Fig. 3). A negative correlation between weed dry weight and grain yield (e.g., -0.46 at 15 DAS) suggests that increased weed dry weight negatively affects grain yield. However, higher dry matter production (e.g., b = 0.66) is positively correlated with grain yield and this conveys that hand weeding practices showed effective weed control in transplanted pearl millet, positively correlating with grain yield and growth parameters, aiding in weed management practices which is similar to the result that was obtained (30). In Fig. 4, regression line captures the overall trend, showing how grain yield decreases as weed dry weight increases. The wider the shaded area, the more variability there is in the relationship. This suggests that reducing weed biomass at early growth stages (30 DAS) is critical for maintaining or improving grain yield. Higher weed biomass at this stage likely competes with the crop for resources like nutrients, water and sunlight, reducing yield. The R^2 values of the weed dry matter accumulation during critical stage @ 15,30,45 DAS were 0.208, 0.685 and 0.547 with pearl millet grain yield, respectively (Fig. 4 A-C). The R^2value for the 30 DAS model is much higher (0.685 vs. 0.208), indicating that weed dry weight at 30 DAS explains a much larger proportion of the variance in the dependent variable compared to weed dry weight at 15 DAS.

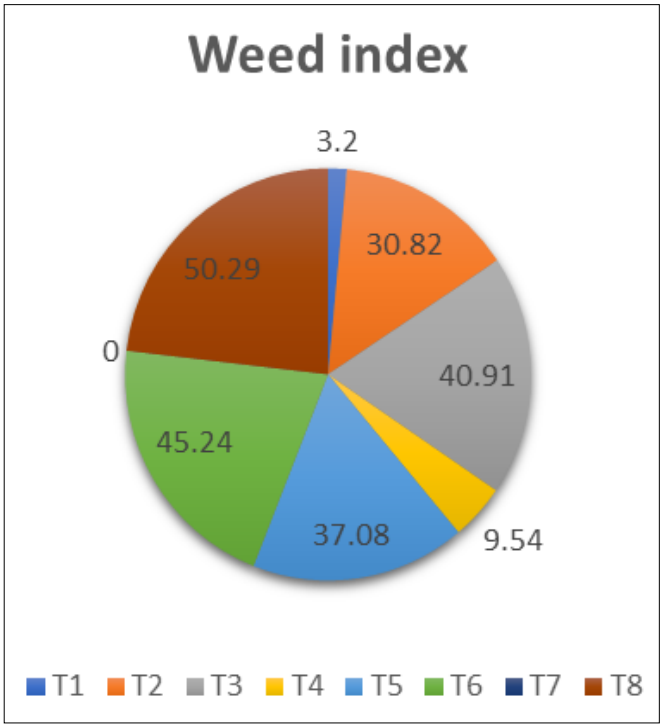
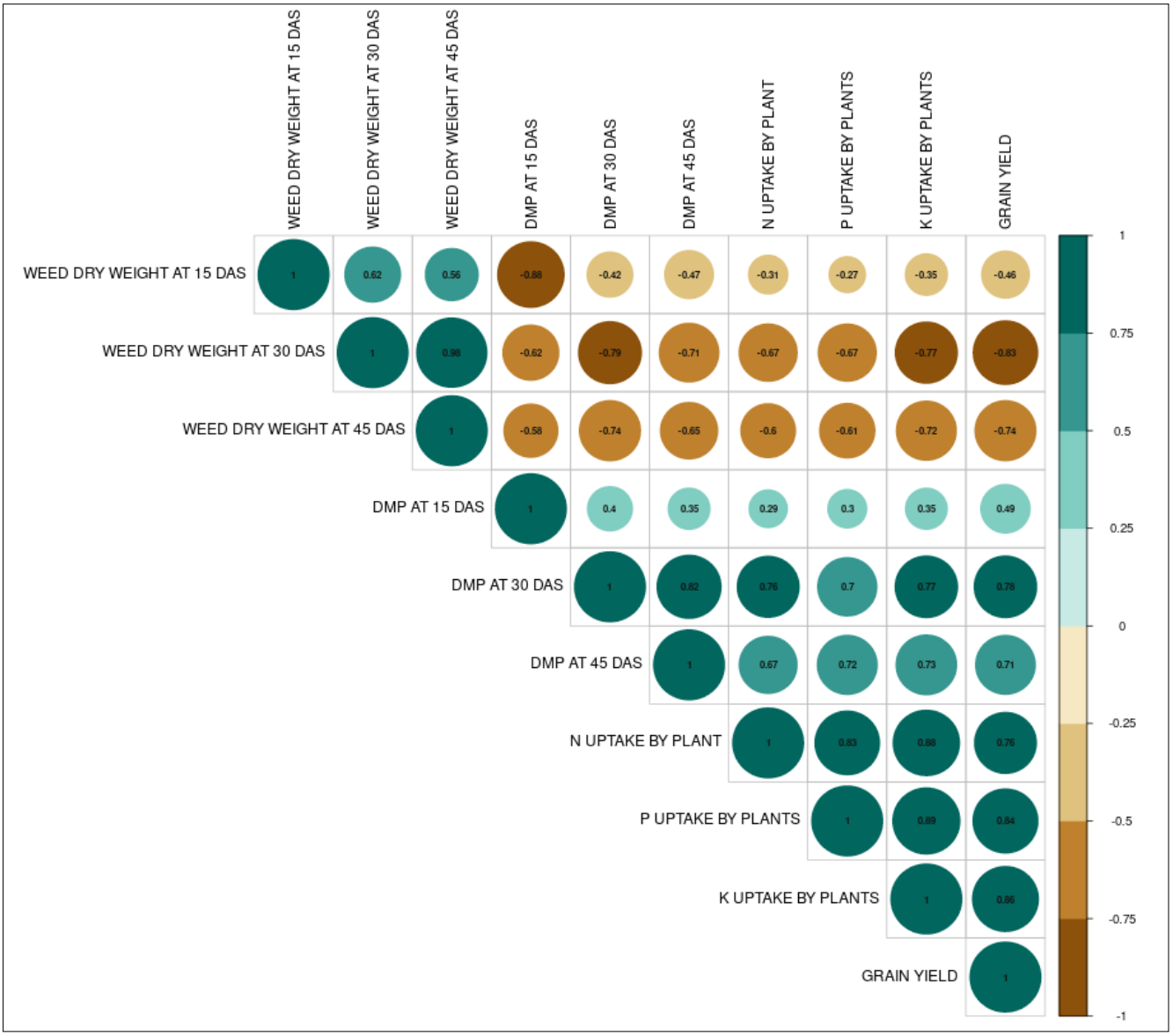


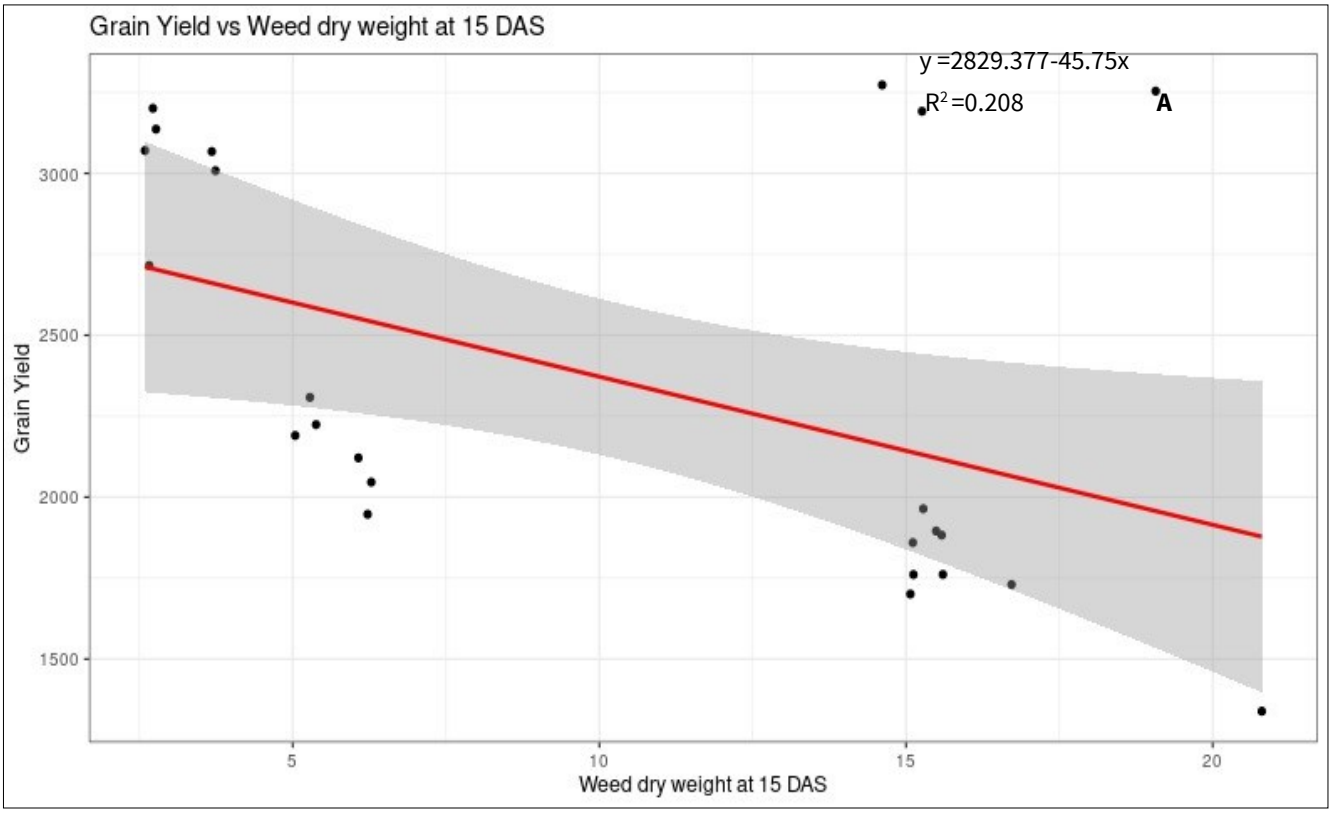
Fig. 3. Effect of different weed management practices on the Weed index (%).

T_1- Pre emergence application of Atrazine 50 % WP @ 0.25kg g a.i. ha^{-1} on 3 DAS + one hand weeding on 25 DAS, T_2-Pre emergence application of Pendimethalin 38.7 % CS @ 1kg a.i. ha^{-1} on 3 DAS + one hand weeding on 25 DAS, T_3-Post emergence application of Tembotrione 34.4 % SC @ 0.01kg a.i ha^{-1} on 4- 5 leaf stage, T_4- Pre emergent application of Atrazine 50 % WP @ 0.25 kg a.i ha^{-1} on 3 DAS + Post emergence application of Tembotrione 34.4 % SC @ 0.01 kg a.i. ha^{-1} on 4- 5 leaf stage, T_5- Pre emergent application of Pendimethalin 38.7 % CS @ 1 kg a.i. ha^{-1} on 3 DAS + Post emergence application of Tembotrione 34.4 % SC @ 0.01 kg a.i ha^{-1} on 4- 5 leaf stage, T_6-Mulching @ 5 tonne/ha,T_7-Hand Weeding twice at 15 DAS and 25 DAS, T_8-Weedy check (Unweeded control).

Conclusion

From the results of the field experiment, it can be concluded that hand-weeding twice at 15 DAS and 25 DAS recorded the lowest density, dry weight of weeds and maximum growth attributes and yield of pearl millet, which was at par with the pre-emergence application of Atrazine 50 % WP at 0.25 kg a.i./ha combined with one hand weeding at 25 DAS and followed by pre-emergent application of Atrazine 50 % WP @ 0.25 kg a.i ha^{-1} on 3 DAS *fb* Post-emergence application of Tembotrione 34.4 % SC @ 0.01 kg a.i. ha^{-1} on 4- 5 leaf stage. Hand-weeding twice at 15 DAS and 25 DAS (T_7) and pre-emergence application of Atrazine 50 % WP at 0.25 kg a.i./ha combined with hand-weeding at 25 DAS(T_1) effectively managed the diverse weed flora, obtaining maximum growth and productivity in pearl millet cultivation during the summer. The present study's findings indicate that implementing effective weed control measures guarantees that Pearl millet receives optimal growth conditions, resulting in enhanced growth, increased yields and augmented resistance to pests and diseases. Consequently, incorporating appropriate weed management strategies is essential for optimizing pearl millet's agricultural and economic potential, particularly in areas where it serves as a fundamental food source.


WEED DRY WEIGHT AT 15 DAS
WEED DRY WEIGHT AT 30 DAS
WEED DRY WEIGHT AT 45 DAS
DMP AT 15 DAS
DMP AT 30 DAS
DMP AT 45 DAS
N UPTAKE BY PLANT
P UPTAKE BY PLANTS
K UPTAKE BY PLANTS
GRAIN YIELD
1
0.62
0.56
-0.88
-0.42
-0.47
-0.31
-0.27
-0.35
-0.46
1
0.98
-0.62
-0.79
-0.71
-0.67
-0.67
-0.77
-0.83
1
-0.58
-0.74
-0.65
-0.6
-0.61
-0.72
-0.74
1
0.4
0.35
0.29
0.3
0.35
0.49
1
0.82
0.76
0.7
0.77
0.78
1
0.67
0.72
0.73
0.71
1
0.83
0.88
0.76
1
0.89
0.84
1
0.86
1
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1


Grain Yield vs Weed dry weight at 15 DAS
y =2829.377-45.75x
R2 =0.208
A
Grain Yield
3000
2500
2000
1500
5
10
15
20
Weed dry weight at 15 DAS

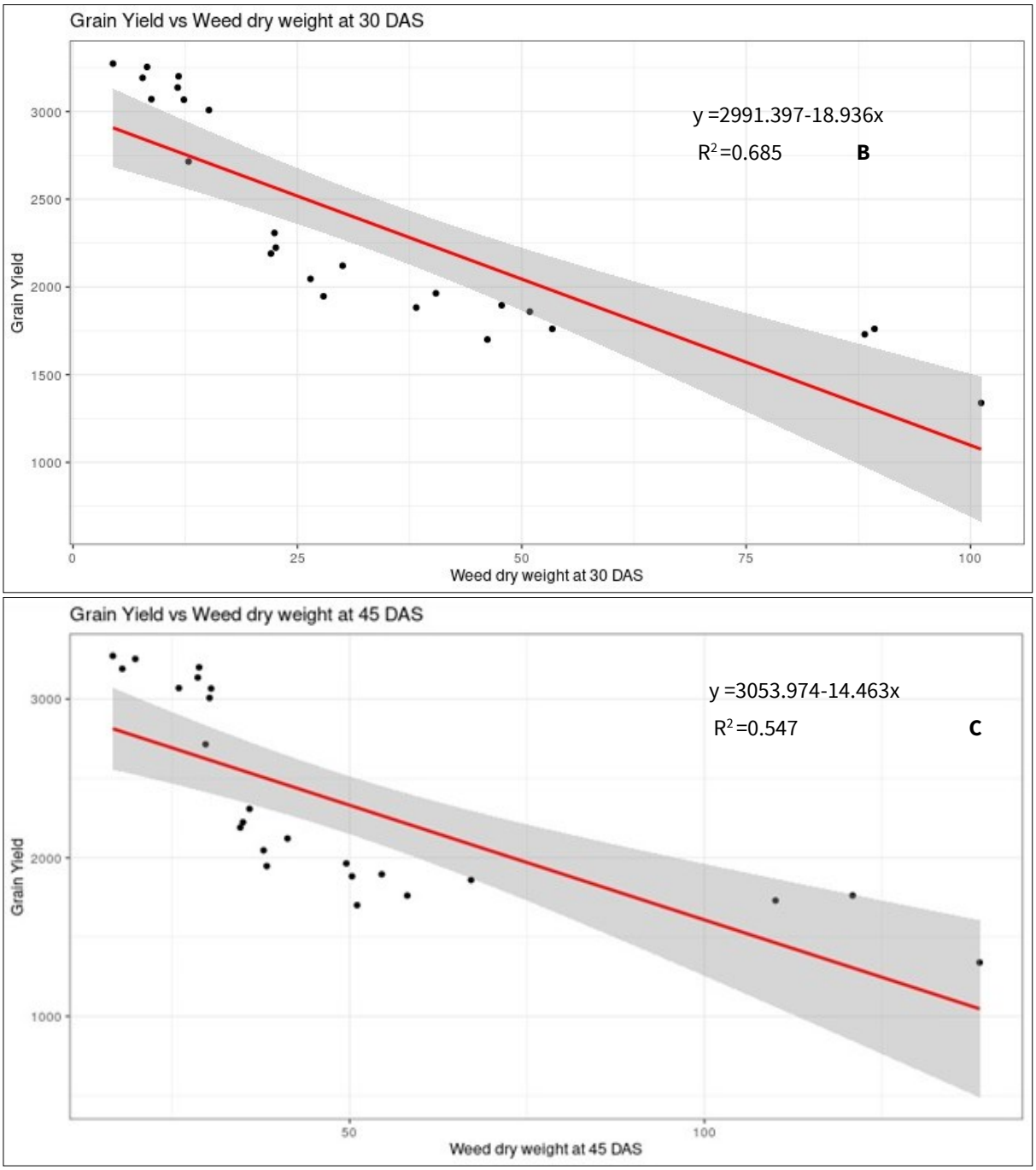


Fig. 4. Correllogram between weed dry weight, dry matter production, nutrient uptake and grain yield.

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Authors' contributions

AMV executed the experiment and collected the data. RB conceptualised and supervised the experiment and analysed the data. AMV prepared the manuscript. CH participated in its design and coordination. RK, PB, RJ gave guidance. SR helped me in the statistical analysis. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The writers admitted not having any conflicts of interest.

Ethical issues: None

References

1. Satyavathi CT, Ambawat S, Khandelwal V, Srivastava RK. Pearl millet: a climate-resilient nutricereal for mitigating hidden hunger and provide nutritional security. Front. Plant Sci. 2021;12:659938. https://doi.org/10.3389/fpls.2021.659938
2. Directorate of millets development Report, Jaipur, Area production and yield of millets during 2011-12 to 2021-22. https://apeda.gov.in/milletportal/files/Statistics_report.pdf
3. Umrani NK, Bhoi PG. Studies on weed control in bajra under dryland conditions. 1982;7:1145-146. https://www.cabidigitallibrary.org/doi/full/10.5555/19830752230

4. Kumar YSR, Kumar R, Baba YA, M. Samruth. Effect of integrated weed management on yield, yield attributes and economics of pearl millet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz]. Int J Curr Microbiol Appl Sci. 2019;8:2629-33. https://doi.org/10.20546/ijcmas.2019.810.303
5. Charul C, Seema D, Sarita, Sheshnath P. Review and outlook of weed management in Pearl millet. Int J Chem Stud. 2018;6 (2):2346-350. https://doi.org/10.13140/RG.2.2.25251.35364
6. Yonli D, Traore H, Kountche BA. Weed and Striga management in pearl millet production systems in sub-Saharan Africa. In Pearl Millet in the 21st Century: Food-Nutrition-Climate resilience-Improved livelihoods. Springer Nature Singapore.2024:395-414. https://doi.org/10.1007/978-981-99-5890-015
7. Lalichetti S, Singh S, Maitra S, Keerthipriya O. Potential role of weed management on growth and productivity of pearl millet: A review. Int J Agric Environ Biotechnol. 2021;14(2):169-73. https://doi.org/10.30954/0974-1712.02.2021.7
8. Sharon XC, Manuel RI, Sharmili K, Kumar D. Evaluation of Mulching Methods and Legume Intercropping on Weed Control Efficiency and Agronomic Traits of Pearl Millet *(Pennisetum glaucum*). Int J Environ Clim Chang. 2023;13(8):1799-808. https://doi.org10.9734/ijecc/2023/v13i82134
9. Oliveira Jr RS, Rios FA, Constantin J, Ishii-Iwamoto EL, Gemelli A, Martini PE. Grass straw mulching to suppress emergence and early growth of weeds. Planta daninha. 2014;32:11-7. https://doi.org/10.1590/S0100-83582014000100002
10. Dhaka BK, Raj R, Dhaka P. Integrated weed management in minor millets: A review. Int J Plant Sci. 2023;35(23):676-90. https://doi.org/0.9734/ijpss/2023/v35i234288
11. Singh G, Sekhon HS. Integrated weed management in pigeonpea [*Cajanus cajan* (L.) Millsp.]. World J Agric Res. 2013;9(1):8691. https://doi.org/10.5829/idosi.wjas.2013.9.1.27213
12. Rajesh Kumar, R C Meena, C Tara, Satyavathi. Integrated weed management in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Int J Agric Sci. 2022;8(1):231-234. https://doi.org/10.15740/has/ijas/18.1/231-234
13. Angmo D, Chopra S. Comparative efficacy of herbicides and hand weeding to control weeds in onion. Indian J Weed Sci. 2020;52 (1):53-7. https://doi.org/10.5958/0974-8164.2020.00009
14. Kaur A, Singh G, Menon S, Kumari K. Integrated weed management: A comprehensive review of conventional, non-conventional, and emerging strategies for sustainable agriculture. J Adv Biol Biotechnol. 2024;27(8):156-67. https://doi.org/10.9734/jabb/2024/v27i8113
15. Kaushik SK, VS Mani. Weed control in direct seeded and transplanted rice. Indian J Weed Sci.1978;10:73-78.
16. Gill GS, Vijaya Kumar K. Weed index-A new method of reporting weed control trials. Indian J Agron.1969;14:96-98. https://cir.nii.ac.jp/crid/1574231874752900224
17. Yoshida S, Cock JH, Parao FT. Physiological aspects of high yield. In: Rice Breeding, International Rice Research Institute, Los Baños.1972.455-69. https://books.irri.org/9711040522_content.pdf
18. Gomez KA, Gomez AA. Statistical procedure for agricultural research. John Wiley and Sons, London. 2003.139-67.
19. Deshveer CL, Deshveer LS. Weed management in pearl millet (*Pennisetum glaucum*) with special reference to *Trianthema portulacastrum.* Indian J Weed Sci. 2005;37(4):212-15.
20. Abusteit E, Absy R, Ismail A, Hassan A. Preliminary study on the effect of certain weeds control strategies on the seed bank of the soil. 2024. https://doi.org/10.21203/rs.3.rs-4220016/v1
21. Gupta SK, Mishra GC, Purushottam. Efficacy of pre and post emergence herbicide on weed control in kharif maize (*Zea mays* L.). Int J Chem Stud. 2018;6(1):1126-29.
22. Gao P, Zhang Z, Shen J, Mao Y, Wei S, Wei J, et al. Weed seed bank dynamics responses to long-term chemical control in a rice-wheat cropping system. Pest Manag Sci. 2020;76(6):1993-2003. https://doi.org/10.1002/ps.5731
23. Sunitha N, Kalyani DL. Weed management in maize (*Zea mays* L.)-A review. Agric Rev. 2012;33(1):70-77. https://arccjournals.com/journal/agricultural-reviews/ARCC565
24. Raman R, Kuppuswamy G, Krishnamoorthy R. Response of weed management practices on the growth and yield of urdbean {*Vigna mungo* L. Hepper}. Legume Res. 2005;28(2):122-24. https://arccjournals.com/journal/legume-research-an-international-journal/ARCC3725
25. Coelho CG, Dalvi LP, Oliveira LS, Oliveira FL. Production and nutrient accumulation of common bean cultivars under competition with weed. Planta daninha. 2019;37:e019214474. https://doi.org/10.1590/S0100-83582019370100151
26. Pradhan DD, Rawal S, Bali A, Dhaka AK, Asif M, Purohit NN. Impact of pre and post-emergence herbicide mixtures in direct seeded rice (*Oryza sativa* L.). Int J Environ Clim Chang. 2023;13 (12):1240-52. https://doi.org/10.9734/ijecc/2023/v13i123787
27. Alptekin H, Ozkan A, Gurbuz R, Kulak M. Management of weeds in maize by sequential or individual applications of pre-and post-emergence herbicides. Agriculture. 2023;13(2):421. https://doi.org/10.3390/agriculture13020421
28. Munde SD, Aghav VD, Pagar RD, Patel JC. Effect of herbicides on weeds and yield of rainy season pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. And Stuntz]. Crop Res. 2012;44(3):288-91. https://doi.org/10.7324/JABB.2023.118222
29. Bhattarai RK, Chaulagain B, Gaywaly P, Karki TB, Neupane R, Das SK. et al. Integrated weed management in summer maize in mid-hills of Nepal. Agron J Nepal. 2022;145-52. https://doi.org/10.3126/ajn.v6i1.47957
30. Lekha SJB, Kumar KU, Silambarasan M, Chetty MR. Correlation and regression of weed, growth and yield attributes of transplanted pearl millet (*Pennisetum glaucum (L.)* R. Br. Emend. Stunz) as affected by weed management practices. Int J Environ Clim Chang. 2023;13(8):844-50. https://doi.org/10.9734/ijecc/2023/v13i82019

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