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Effect of nutrient and weed management practices on weed dynamics, growth and yield of wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during rabi seasons 2022-23 and 2023-24 to evaluate the effect of nutrient and weed management practices on weed density, weed dry matter accumulation, growth and grain yield of wheat under irrigated conditions. The study comprised four nutrient management levels (control, 50, 75 and 100% RDN) and seven weed management practices (control, hand weeding, hoeing, intercropping with mustard, straw mulch followed by hand weeding, straw mulch followed by hoeing, and green manuring). Results showed that nutrient levels had a non-significant influence on weed density at 60 DAS though weed dry matter increased progressively with higher nitrogen doses. Conversely, weed management practices exerted a significant effect on weed density and dry matter in both years. Hand weeding and hoeing at 25 & 50 DAS recorded the lowest weed density and dry matter accumulation, whereas the highest values were observed under weedy check. Growth parameters such as plant height and dry matter accumulation at 60 DAS, as well as grain yield, significantly improved with 100% RDN and effective weed management practices. Among nutrient levels, 100% RDN recorded the highest grain yield (4170 and 4418 kg ha⁻¹ during 2022-23 and 2023-24, respectively). Among weed control treatments, hoeing and hand weeding at 25 & 50 DAS resulted in superior growth and yield performance.

Keywords: Wheat, nutrient management, weed dynamics, mechanical weed control, grain yield

Introduction

Wheat (*Triticum aestivum* L.) remains one of the world's leading cereal crops and plays a central role in global food and nutritional security. In India, it is a dominant rabi-season crop and contributes substantially to national food grain production. Despite its importance, sustaining high wheat yields is often constrained by declining soil fertility, imbalanced nutrient application, and severe weed infestation, especially in semi-arid and arid regions. Weed competition for essential growth resources such as nutrients, water, light, and space significantly hampers crop performance and nutrient-use efficiency. Earlier studies have indicated that unchecked weed growth can reduce wheat yields by 30-60%, depending on the intensity and composition of weed flora (Singh *et al.*, 2018; Patel *et al.*, 2019)^[14, 11].

Efficient nutrient management is a critical determinant of wheat productivity. The use of organic nutrient sources including neem cake, vermicompost, and NADEP compost enhances soil health by improving physical structure, nutrient availability, and biological activity. Research suggests that supplying nitrogen through organic or integrated sources positively influences plant growth parameters, dry matter accumulation, and grain yield (Kumar *et al.*, 2020; Meena *et al.*, 2021; Yadav *et al.*, 2022)^[5, 8, 17]. Applying different levels of recommended nitrogen dose (RDN)—such as 50, 75, and 100%—from organic sources promotes slow and steady nutrient release, reduces losses, and contributes to long-term improvements in soil fertility (Singh *et al.*, 2023)^[13].

Weed management is another crucial factor in achieving optimal wheat productivity. A range of cultural and mechanical practices—including hand weeding, hoeing, mulching, intercropping, and green manuring—has proven effective in reducing weed populations and enhancing crop

competition. Timely hand weeding and hoeing have shown significant success in curbing weed growth and boosting wheat yield (Parihar *et al.*, 2024; Patel *et al.*, 2022) ^[9, 10]. Mulching with crop residues is known to suppress weed emergence, conserve moisture, and improve the microenvironment for crop growth (Wasaya *et al.*, 2022; Meena & Jakhar, 2023) ^[17, 7]. Intercropping systems, such as wheat paired with mustard, can modify canopy structure and utilize resources more efficiently, thereby reducing weed pressure (Agegnehu *et al.*, 2021) ^[1]. Similarly, green manuring prior to wheat sowing enriches soil organic matter, improves nutrient cycling, and minimizes early-season weed emergence (Kumar *et al.*, 2024) ^[6].

A combined approach that integrates nutrient management with effective weed control is essential for maximizing wheat productivity in a sustainable manner. Evidence suggests that coupling organic nutrient inputs with mechanical and cultural weed management strengthens crop competitiveness, improves soil health, and enhances yield stability (Rahman *et al.*, 2021; Chauhan & Mahajan, 2022) ^[12, 2]. Hence, assessing the performance of various nutrient levels alongside diverse weed management strategies is vital for developing sustainable and productive wheat cultivation practices across different agro-climatic environments.

Materials and Methods

The field study was carried out for two consecutive *rabi* seasons (2022-23 and 2023-24) at the Organic Farm of the Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan (Pin: 313001). The experimental site is situated at 74°42' E longitude and 24°35' N latitude, with an elevation of 581.13 m above mean sea level. Wheat was sown in November and harvested in March during both cropping years. The soil at the location is classified as clay-loam, comprising about 36.5% sand, 28.2% silt, and 34.6% clay in each year. The soil reaction was slightly alkaline with a pH of approximately 8.10, and the electrical conductivity averaged 1.02 dS m⁻¹. In terms of nutrient status, the soil tested medium in available nitrogen (278.42 and 279.78 kg ha⁻¹) and phosphorus (18.07 and 18.77 kg ha⁻¹) and high in available potassium (312.45 and 313.09 kg ha⁻¹).

A total of twenty-eight treatment combinations were evaluated in the experiment, comprising three organic nitrogen management practices (N₁-N₃) along with a control (N₀), and six weed management practices (W₁-W₆) along with a control (W₀). The organic nitrogen treatments included: N₀ - control without manure; N₁ - 50% of the recommended nitrogen dose supplied through an equal proportion of neem cake, vermicompost and NADEP compost; N₂ - 75% RDN using the same combination of organic sources; and N₃ - 100% RDN through a similar mixture of the three organic manures. The weed management treatments consisted of W₀ - control without weed control; W₁ - hand weeding at 25 and 50 DAS; W₂ - hoeing at 25 and 50 DAS; W₃ - intercropping wheat with mustard in a 4:2 row proportion; W₄ - straw mulch followed by hand weeding at 30 DAS; W₅ - straw mulch followed by hoeing at 30 DAS; and W₆ - green manuring at 25 DAS. The recommended nitrogen dose for wheat was 120 kg ha⁻¹.

The experiment was carried out using wheat variety Raj 4079 following the standard agronomic practices recommended for the Udaipur region. Sowing was performed on 8 November during 2022-23 and on 14 November during 2023-24. Organic manures were incorporated into the soil according to the treatment schedule, and the field was left undisturbed for 15 days to allow partial decomposition before sowing. Irrigation

was applied using bore-well water at critical growth stages of the crop. Weed control measures were performed according to the respective treatments. Standard plant protection practices were adopted to safeguard the crop from pests and diseases throughout the growing period.

Weed density at 60 days after sowing (DAS) was recorded using a quadrat of 0.25 m² or 1.0 m², depending on the protocol maintained across treatments. Quadrats were placed randomly at two to three locations within each plot while avoiding border rows. All weeds within the quadrat were identified to species level and counted. Weed density (number m⁻²) was calculated by converting species-wise counts based on the quadrat area. For weed dry matter, the same quadrat locations used for density were sampled. Species-wise weed samples were uprooted or cut at ground level. Samples were cleaned of soil particles and foreign materials and then oven-dried at 65 ± 5°C until a constant weight was obtained (typically 48-72 hours). The dry biomass was then weighed using a precision balance and expressed as g m⁻² after adjusting for quadrat size. Grain yield was recorded from the net plot area, following threshing and winnowing, and converted to kg ha⁻¹.

Data collected from the experiments were analyzed using analysis of variance (ANOVA) as per the procedures outlined by Panse and Sukhatme. Pooled analysis across the two years was performed to determine overall treatment effects. Treatment means were compared using the critical difference (CD) at the 5% probability level wherever the F-test indicated significance.

Results and Discussion

Nutrient management

Weed Density at 60 DAS

The data presented in Table 1 revealed that nutrient management practices did not significantly influence weed density at 60 DAS during both years of experimentation. Although statistically non-significant, a marginal numerical increase in narrow-leaf, broad-leaf, and total weeds was observed with increasing nutrient levels from control to 100% RDN. The total weed density increased from 6.30 to 6.58 weeds m⁻² (2022-23) and from 6.68 to 6.92 weeds m⁻² (2023-24). This slight increase can be attributed to the improvement in soil nutrient availability which favors the germination and growth of both crop plants and weed flora. Several studies have also reported that nutrient-enriched environments stimulate weed emergence, particularly fast-growing species that effectively exploit available resources (Chauhan & Mahajan, 2022; Singh *et al.*, 2023) ^[2, 13].

Weed Dry Matter Accumulation at 60 DAS

Weed dry matter increased significantly with the rise in nutrient levels from control to 100% RDN. Narrow-leaf weed dry matter ranged from 7.28-10.43 g m⁻² (2022-23) and 9.21-12.52 g m⁻² (2023-24), while broad-leaf weeds varied from 30.76-46.31 g m⁻² and 35.44-51.00 g m⁻², respectively. Total WDMA increased from 38.05 to 56.74 g m⁻² (2022-23) and 44.65 to 63.52 g m⁻² (2023-24). The significant increase in weed biomass with higher nutrient application is attributable to enhanced soil fertility, which stimulates the growth of both crops and nutrient-responsive weed species. Nutrient-rich soils promote faster weed growth due to their high competitive ability, prolific branching, and rapid resource acquisition compared to wheat. This trend is widely reported in intensive cereal systems, where increased N availability facilitates dominance of aggressive species such as *Phalaris minor*, *Chenopodium album*, and *Rumex dentatus* (Chauhan & Opena, 2020; Singh *et al.*, 2023) ^[2, 13]. The higher accumulation of dry matter by broad-leaf weeds compared to

narrow-leaf weeds may be associated with their larger leaf area, thicker stems, and greater photosynthetic capacity, enabling them to utilize applied nutrients more efficiently. Similar observations were noted by Pandey in N-fertilized wheat fields.

Growth parameter

Plant height at 60 DAS

Nutrient management exerted a significant influence on plant height at 60 DAS. Plant height increased progressively with incremental nitrogen supply, ranging from 47.04-48.41 cm under the control to 59.96-61.16 cm under 100% RDN during both years. The improvement in plant height under higher N levels can be attributed to greater availability of nitrogen, which promotes cell division, leaf expansion, and chlorophyll synthesis, leading to improved vegetative growth. Similar results were reported by Meena *et al.* (2021)^[8] and Singh *et al.* (2023)^[13], who observed that adequate nitrogen enhances early crop vigor and biomass accumulation in wheat.

Dry matter accumulation at 60 DAS

Dry matter accumulation (DMA) followed a pattern similar to plant height, with the lowest values under the control (38.43-39.81 g m⁻²) and the highest under 100% RDN (47.90-49.56 g m⁻²). Increased DMA under higher RDN levels is due to improved photosynthetic efficiency, enhanced nutrient uptake, and stronger tiller formation, ultimately reflecting greater assimilatory surface. These findings corroborate the observations of Yadav *et al.* (2022)^[17], who reported that higher nitrogen doses optimize source-sink balance and contribute to higher biomass production in wheat.

Grain Yield

Grain yield also increased significantly with increasing RDN levels. The yield improved from 3061-3280 kg ha⁻¹ under the control to 4170-4418 kg ha⁻¹ under 100% RDN. Enhanced yield under higher nitrogen regimes is associated with greater dry matter accumulation, improved tiller survival, and better translocation of assimilates to grains. Similar yield gains with increasing nitrogen have been documented by Patel and Parihar *et al.* (2024)^[9], emphasizing nitrogen's role in determining yield attributes.

Weed management practices

Weed Density at 60 DAS

The weed management practices, on the other hand, exhibited a highly significant influence on weed density for all weed groups in both years. The highest weed density was recorded under the weedy check, with total weeds of 9.04 and 9.26 weeds m⁻² during 2022-23 and 2023-24, respectively. Absence of any control measure allowed uninterrupted weed emergence and competition, resulting in higher infestations. This aligns with the observations of Yadav *et al.* (2021)^[16], who reported that lack of early weed control in wheat leads to rapid weed establishment due to early-season resource capture.

Among the weed management practices, hand weeding at 25 & 50 DAS was the most effective, followed by hoeing at 25 & 50 DAS, which recorded the lowest total weed densities (4.57-5.22 weeds m⁻²). Timely manual operations at early and mid-tillering stages effectively uproot both narrow-leaf and broad-leaf weeds, thereby reducing subsequent weed recruitment. Mechanical weeding disrupts the root system, buries small seedlings, and creates an unfavorable soil environment, which explains the substantial reduction. Similar results were documented by Patel *et al.* (2022)^[10] and Khan *et al.* (2020)^[4], who highlighted the

superiority of double manual weeding in reducing weed pressure in wheat. Straw mulch followed by hand weeding or hoeing at 30 DAS recorded moderate weed densities (5.74-6.29 weeds m⁻²). Straw mulch acts as a physical barrier that intercepts light reaching the soil surface, reducing weed seed germination. The subsequent intercultural operation at 30 DAS removes escaped weeds, contributing to effective control. This is consistent with the findings of Meena & Jakhar (2023)^[7], who reported that straw mulch significantly suppresses early-season weed emergence by reducing soil temperature fluctuations and light penetration.

The intercropping of wheat with mustard (4:2) resulted in comparatively higher weed densities than other weed control practices but lower than the weedy check. This may be attributed to partial canopy shading by mustard which moderately inhibits weed growth but also leads to interspecific competition between crop and intercrop, limiting its weed suppression potential. Similar outcomes were reported by Agegnehu *et al.* (2021)^[1], noting that intercropping alters microclimate but is less effective than mechanical methods in suppressing weeds. Green manuring at 25 DAS also reduced weed density moderately. Incorporation of green manure improves soil microbial activity and disrupts weed seedlings; however, the effect may not be as immediate or strong as physical weed control. The results support previous reports by Kumar *et al.* (2024)^[6], who observed that green manuring enhances soil properties but has a delayed effect on weed suppression.

Weed Dry Matter Accumulation at 60 DAS

The weed dry matter accumulation at 60 DAS followed a similar trend to weed density. The highest weed dry matter accumulation at 60 DAS was recorded in the unweeded control (81.70-88.53 g m⁻²), indicating intense crop-weed competition. Two manual weedings at 25 & 50 DAS resulted in the lowest total weed dry matter accumulation at 60 DAS, i.e., 26.78 g m⁻² (2022-23) and 33.51 g m⁻² (2023-24). The significant reduction in dry weight highlights the effectiveness of this practice in eliminating weeds before they accumulate biomass, thereby reducing their competitive ability for moisture, nutrients, and solar radiation. These results align with the findings of Singh *et al.* (2023)^[13] and Parihar *et al.* (2024)^[9], who also reported that timely weed removal drastically reduces WDMA in wheat.

Hoeing at 25 & 50 DAS also significantly reduced WDMA (27.74-34.63 g m⁻²), reflecting its ability to uproot deeper-rooted weeds and disturb the soil surface. Straw mulch treatments (mulch followed by hand weeding or hoeing) registered moderate WDMA levels (35.77-42.79 g m⁻²). The mulch layer likely smothered emerging weeds and reduced the growth of established ones, consistent with findings by Gaihre *et al.* (2022)^[3]. Intercropping with mustard (4:2) resulted in relatively higher WDMA compared to other weed control practices (74.10-79.82 g m⁻²), though still much lower than the control. The partial reduction can be explained by competitive canopy architecture and space sharing in intercropping systems, as noted by Wasaya *et al.* (2022)^[15] and Agegnehu *et al.* (2021)^[1].

Growth parameters

Plant Growth at 60 DAS

Weed control practices significantly influenced plant height. The lowest plant height was noted in the weedy check (41.13-42.45 cm) due to intense weed competition for nutrients, moisture, and space, suppressing early vigor. The maximum plant height was obtained under hoeing (62.38-63.71 cm) and hand weeding at 25 & 50 DAS (61.92-63.24 cm). Effective weed removal during

critical periods of crop-weed competition allowed wheat plants to utilize growth resources efficiently, thereby enhancing plant height. These findings align with Rahman *et al.* (2021)^[12] and Gaihre *et al.* (2022)^[13], who reported significant improvement in plant growth when weed infestation was minimized during early growth stages.

Dry matter accumulation at 60 DAS

Dry matter accumulation was also significantly affected by weed management practices. The lowest DMA was observed in the weedy check (39.03-40.59 g m⁻²), attributed to heavy weed interference reducing photosynthetic capacity and nutrient uptake. The highest DMA occurred under straw mulch-based hoeing (47.51-49.01 g m⁻²) and straw mulch + hand weeding (46.94-48.44 g m⁻²). The mulch layer likely reduced weed emergence and improved soil moisture retention, resulting in a favorable microenvironment for wheat growth. These

observations corroborate the reports of Choudhary and Wasaya *et al.* (2022)^[15], who highlighted the advantages of mulch in enhancing wheat biomass.

Grain Yield

Weed management practices produced significant variations in grain yield. The weedy check yielded the lowest, reflecting heavy yield losses from unchecked weed competition. The highest grain yield was recorded under hoeing at 25 & 50 DAS and hand weeding, showing clear superiority due to effective weed suppression and consequent improvement in crop growth parameters. Straw mulch combinations also contributed substantially to yield by reducing early weed load and conserving soil moisture. These findings align with the work of Singh *et al.* (2023)^[13], who emphasized that integrated weed management significantly enhances wheat productivity under field conditions.

Table 1: Effect of nutrient and weed management practices on weed density at 60 DAS of wheat

Treatments	Weed density (m ⁻²) at 60 DAS					
	Narrow leaf weeds		Broad leaf weeds		Total weeds	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
Nutrient management						
Control	2.93 (8.82)	3.17 (10.20)	5.62 (33.23)	5.92 (36.24)	6.30 (42.05)	6.68 (46.43)
50% RDN*	2.97 (9.03)	3.21 (10.43)	5.71 (34.04)	6.01 (37.21)	6.40 (43.07)	6.78 (47.63)
75% RDN	3.00 (9.22)	3.22 (10.56)	5.76 (34.76)	6.06 (37.84)	6.45 (43.98)	6.83 (48.40)
100% RDN	3.04 (9.48)	3.26 (10.77)	5.88 (35.95)	6.15 (38.74)	6.58 (45.44)	6.92 (49.51)
S.Em.±	0.044	0.038	0.076	0.073	0.079	0.073
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management						
Control	4.43 (19.13)	4.61 (20.72)	7.92 (62.18)	8.07 (64.60)	9.04 (81.30)	9.26 (85.32)
Hand weeding at 25 & 50 DAS	2.21 (4.38)	2.43 (5.42)	4.05 (16.21)	4.56 (20.34)	4.57 (20.59)	5.12 (25.76)
Hoeing at 25 & 50 DAS	2.25 (4.57)	2.48 (5.65)	4.19 (17.13)	4.65 (21.26)	4.70 (21.71)	5.22 (26.91)
Intercropping with mustard (4:2)	4.03 (15.78)	4.16 (16.79)	7.39 (54.16)	7.35 (53.67)	8.39 (69.94)	8.42 (70.46)
Straw mulch fb hand weeding at 30 DAS	2.51 (5.89)	2.82 (7.57)	5.28 (27.63)	5.67 (31.85)	5.80 (33.52)	6.29 (39.42)
Straw mulch fb hoeing at 30 DAS	2.47 (5.62)	2.79 (7.31)	5.23 (26.87)	5.57 (30.54)	5.74 (32.50)	6.19 (37.84)
Green manuring at 25 DAS	3.00 (8.59)	3.22 (9.96)	6.14 (37.30)	6.38 (40.29)	6.80 (45.89)	7.11 (50.25)
S.Em.±	0.038	0.045	0.078	0.074	0.076	0.074
C.D. (P=0.05)	0.109	0.127	0.223	0.209	0.215	0.211

*1/3 Neem cake + 1/3 Vermicompost + 1/3 NADEP compost

**Data subjected to $\sqrt{X+0.5}$ transformation and figures in parenthesis are original weed count m⁻²

Table 2: Effect of nutrient and weed management practices on weed dry matter accumulation (species wise) at 60 DAS of wheat

	Weed dry matter accumulation (g m ⁻²)					
	Narrow leaf weeds		Broad leaf weeds		Total weeds	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
Nutrient management						
Control	7.28	9.21	30.76	35.44	38.05	44.65
50% RDN*	8.51	10.53	36.06	40.45	44.57	50.98
75% RDN	9.51	11.53	41.59	46.12	51.10	57.65
100% RDN	10.43	12.52	46.31	51.00	56.74	63.52
S.Em.±	0.240	0.238	0.799	1.028	1.011	1.207
C.D. (P=0.05)	0.832	0.822	2.765	3.556	3.498	4.178
Weed management						
Control	15.15	16.85	66.55	71.68	81.70	88.53
Hand weeding at 25 & 50 DAS	5.51	7.54	21.26	25.97	26.78	33.51

Hoeing at 25 & 50 DAS	5.85	7.84	21.89	26.78	27.74	34.63
Intercropping with mustard (4:2)	13.16	15.10	60.94	64.71	74.10	79.82
Straw mulch <i>fb</i> hand weeding at 30 DAS	7.19	9.33	29.34	33.47	36.53	42.79
Straw mulch <i>fb</i> hoeing at 30 DAS	6.95	9.21	28.82	32.98	35.77	42.19
Green manuring at 25 DAS	8.73	10.74	41.95	47.18	50.68	57.92
S.Em.±	0.212	0.236	0.894	1.120	0.952	1.179
C.D. (P=0.05)	0.604	0.670	2.543	3.184	2.707	3.352

* $\frac{1}{3}$ Neem cake + $\frac{1}{3}$ Vermicompost + $\frac{1}{3}$ NADEP compost

Table 3: Effect of nutrient and weed management practices on plant height and dry matter accumulation at 60 DAS, grain yield of wheat

	Plant height at 60 DAS		Plant dry matter accumulation (g m ⁻²) at 60 DAS		Grain yield (kg ha ⁻¹)	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
Nutrient management						
Control	47.04	48.41	38.43	39.81	3061	3280
50% RDN*	52.08	53.48	42.30	43.72	3688	3923
75% RDN	56.29	57.59	45.21	46.77	3949	4184
100% RDN	59.96	61.16	47.90	49.56	4170	4418
S.Em.±	1.02	0.96	0.67	0.73	55	53
C.D. (P=0.05)	3.51	3.34	2.32	2.54	190	183
Weed management						
Control	41.13	42.45	39.03	40.59	41.13	42.45
Hand weeding at 25 & 50 DAS	61.92	63.24	44.32	45.81	61.92	63.24
Hoeing at 25 & 50 DAS	62.38	63.71	45.21	46.70	62.38	63.71
Intercropping with mustard (4:2)	46.56	47.90	39.33	40.87	46.56	47.90
Straw mulch <i>fb</i> hand weeding at 30 DAS	56.46	57.81	46.94	48.44	56.46	57.81
Straw mulch <i>fb</i> hoeing at 30 DAS	57.08	58.38	47.51	49.01	57.08	58.38
Green manuring at 25 DAS	51.34	52.62	41.86	43.33	51.34	52.62
S.Em.±	1.25	1.19	0.75	0.71	1.25	1.19
C.D. (P=0.05)	3.56	3.37	2.12	2.02	3.56	3.37

* $\frac{1}{3}$ Neem cake + $\frac{1}{3}$ Vermicompost + $\frac{1}{3}$ NADEP compost

Conclusion

The study demonstrated that nutrient supply up to 100% RDN ($\frac{1}{3}$ Neem cake + $\frac{1}{3}$ Vermicompost + $\frac{1}{3}$ NADEP compost) significantly enhanced wheat growth and grain yield. Although nutrient levels did not significantly affect weed density, higher nutrient availability increased weed dry matter. Mechanical weed management practices such as hand weeding and hoeing at 25 & 50 DAS proved highly effective in reducing weed density and dry matter accumulation, resulting in greater productivity. Integrated application of 100% RDN ($\frac{1}{3}$ Neem cake + $\frac{1}{3}$ Vermicompost + $\frac{1}{3}$ NADEP compost) along with timely mechanical weed control is recommended for optimizing growth, suppressing weed interference, and maximizing wheat yield under irrigated conditions.

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