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Effect of nutrient management and weed control practices on growth parameters of wheat (*Triticum aestivum* L.)

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Abstract
An experiment was carried out at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (Uttar Pradesh) in two consecutive years (2022-23 & 2023-24) in Rabi season to find out the effect of nutrient management and weed control practices on growth parameters of various treatments on wheat crop. The experiment was laid out in split plot design with three nutrient levels and six weed control practices and replicated thrice. Application of 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit noted greater effect on plant height, number of tiller, leaf area index and dry matter accumulation during both years of experimentation. In case of weed management, spray of Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) found more effective to increase the growth of wheat during both year of investigation. This treatment having better weed control and higher nutrient uptake resulted in higher growth. It can be concluded that application of 75% RDF +10 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit with the spraying of Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) proved better to increase the growth of wheat crop.

Keywords: Nutrient, growth, nano-urea, herbicide and wheat

Introduction
Wheat (*Triticum aestivum* L.) belongs to family Poaceae, is the most important cereal crop for the majority of world population. It is the most important staple food of about two billion people (36% of the world population) worldwide. It provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally and straw is a good source of feed for a large population of cattle in our country. It exceeds in acreage and production every other grain crop (including rice, maize, etc) and therefore, the most important cereal grain crop of the world, which is cultivated over a wide range of climatic conditions. It is primarily grown in temperate regions at a high altitude as well as medium altitude in tropical and subtropical regions. It is grown in the world with an area of 215.9 million hectare, production 771.78 million tonnes and productivity of 3.53 tonnes per hectare. In India, it is grown in an area of 31.61 million hectare, production 109.52 million tonnes with a productivity of 3544 kg per hectare and Uttar Pradesh having first rank in respect to both area (9.85 million hectare) and production (31.16 million tonnes) with a productivity of 3604 kg per hectare (Agriculture Statistics at a Glance, 2021) [2].
Among the different management practices, nutrient management is crucial in crop nutrition for achieving higher yields (Raun and Johnson, 1999) [11]. The soils of India are deficient in nitrogen and are supplemented with chemical fertilizer for enhancing the crop productivity. Nitrogenous fertilizers play a vital role in modern farm technology, however only 20-50% of the soil applied nitrogen is recovered by the annual crops (Bajwa, 1992) [3]. The left-over nitrogen is lost from the soil system through denitrification, volatilization and leaching.
Nutrient application in agricultural system is expected to increase in the coming years to produce more food, feed and fiber from lesser land area. Efficient utilization of applied nutrients will be the key to sustainability in such high input-high output systems. Efficient fertilization is important from both economic and environmental point of view.

It is synonymous with minimizing nutrient losses to the environment, while optimizing crop yields. It is appropriate here to mention that efficient nutrient use is essentially an offspring of balanced fertilizer use and sound management practices and decision. The balance nutrition plays an important role in raising the production potential of wheat because the wheat crop is extremely responsive to applied nutrient through numerous sources. Among various nutrients, nitrogen is required by wheat crop in large amount and usually supplied through outside sources like fertilizer and manures as most of the soil in wheat growing areas are deficient in nitrogen availability.

Nano-fertilizers are the important tools in agriculture to improve crop growth, yield and quality parameters with increase nutrient use efficiency, reduce wastage of fertilizers and cost of cultivation. Nano-fertilizers are very effective for precise nutrient management in precision agriculture with matching the crop growth stage for nutrient and may provide nutrient throughout the crop growth period. Nano-fertilizers increase crop growth up to optimum concentrations further increase in concentration may inhibit the crop growth due to the toxicity of nutrient. (Qureshi *et al*., 2018) [10].

Among numerous factors answerable for low yield, weeds infestation and their management is one of the important factors. Weed competes with crop plants which results in yield reduction by 20-50%. The prominent weeds distinguished in wheat fields are *P. minor, Chenopodium album, Melilotus alba, Fumeria parviflora, Medicago denticulata, Vicia hirsuita, Vicia sativa, Avena ludoviciana, Coronopus didymus* and *Reumex acetocel.*

Material and Methods

The field experiment was conducted during 2022-23 and 2023-24 at Agronomy Research farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). Geographically the experimental site falls under sub- tropical climate of Indo-gangatic plains (IGP), the soil of the experimental field was silty loam, saline in reaction (*p*H 8.40), low in organic carbon (0.32%), available nitrogen (174.30 kg N/ha), and medium in available phosphorus (16.10 kg P/ha) and potassium (248.34 kg/ha). Treatments were laid down in a split plot design, replicated three times with 2 factors. First factor included of three nutrient levels in main plot *viz*. 100% RDF (150:60:40 kg ha^{-1}), 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit and 50% RDF + 15 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit and six weed control practices in sub-plot *viz*. Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1}), Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}), Sulfosulfuron + Carfentrazone (25 + 20 g a.i. ha^{-1}), Sulfosulfuron + Carfentrazone (25 + 20 g a.i. ha^{-1}), Clodinofop + Carfentrazone (60 + 20 g a.i. ha^{-1}), Weed free, and Weedy check. In all, there were 18 treatment combinations included in the experiment. Wheat variety 'HD-2967' was sown on 25 November, 2022 and 27 November, 2023 with 100kg seed/ha, keeping row-to-row distance of 20cm during both the years of experimentation. Nitrogen was applied as per treatment, but full amount of P and K were applied at the time of sowing and FYM was applied as per treatments and incorporated into the soil before the sowing of the crop. As per treatments, all the post-emergence herbicides were dissolved in water and applied 35 days after sowing, using knapsack sprayer fitted with flat- fan nozzle. Spray of nono-urea was done at 45 DAS with 315 liter water solution ha^{-1}.The experimental field was divided into 54 plots. Each gross plot size was 4.0 m x 5.0 m and net plot size was 3.6 m x 4.0 m and row to row distance was maintained 20 cm. The numbers of tillers, plant height, dry matter accumulation, leaf area index, were counted at 30, 60, 90 DAS and at harvest stages on per square meter basis. The leaf area index was calculated by the following formula.

$$LAI = \frac{L}{A}$$

Where,
LAI - Leaf area index
L - Leaf area (cm^2)
A - Land area (cm^2)

Results and Discussion

Growth parameters

Crop growth was measured in terms of plant height, number of tillers, leaf area index and dry matter accumulation per square meter. The results of these characters are summarized in the form of tables.

Plant height

The plant height was recorded at 30, 60, 90 DAS and at harvest presented in Table-1 and depicted in fig.1a and fig.1b. The Results of the experiment from two years revealed that among nutrient levels application of 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit recorded significantly highest plant height over rest of the fertility levels this was due to application of combined fertility levels like RDF, FYM, and nano-urea that applied in different stage of crop growth that these fertilizers found better to fertile the plant that cause higher plant height. Whereas, it was at par with treatment F_1: 100% RDF (150:60:40 kg ha^{-1}). And the lowest plant height was recorded with F_3: 50% RDF + 15 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit. Similar result was reported by Khokhar and Nepalia (2010) [7].

Among weed management levels spray of Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) recorded highest plant height and being at par with Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1}). These treatments were significantly superior over rest of the herbicidal treatments; this was due to control of grassy and broad leaved weeds by these herbicides. Whereas the highest and lowest plant height was recorded with weed free and weedy check. (Table: 1) Kumar *et al.* (2011) [8] and Bharat *et al.* (2012) [4] reported the same result.

Number of tillers m^{-2}

Number of tillers were significantly affected due to nutrient management and weed control practices at all crop growth stages except at 30 DAS during both the years' of investigation where the difference was non-significant during both the years (Table-2).

Highest number of tillers m^{-2} (215.20, 218.42), (294.53, 296.37), (309.85, 311.72), and (303.78, 305.88) was recorded with 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit at 30, 60, 90 DAS and at harvest respectively but being at par with 100% RDF (150:60:40 kg ha^{-1}) during both the year of investigation (table: 2). Higher number of tillers in these treatments were due to adequate amount of nutrients at active growth stages that supplied by RDF, FYM and nano-urea. Singh *et al.* (2007) [14], Desai *et al.* (2015) [5] and Aatif *et al.* (2017) [1] reported the similar result.

In case of weed control practices, weed free treatment resulted the maximum number of tillers m^{-2} (217.33, 220.50), (296.63, 297.61), (312.23, 314.13), and (306.10, 308.23) *viz*. 30, 60, 90

DAS and at harvest. Whereas, the minimum number of tiller was recorded with weedy check. Among herbicidal treatments application of Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}), noted the maximum number of tillers followed by Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1}) and Sulfosulfuron + Carfentrazone (25 + 20 g a.i. ha^{-1}) during both the years of investigation respectively. The maximum numbers of tillers under these treatments were due to control of grassy and broad leaved weeds by herbicides (Table-2). Similar result was found by Singh *et al.* (2018) [13].

Leaf area index

The data presented in Table-3 indicated that the leaf area index of wheat crop was significantly influenced by various nutrient management and different weed control practices during both the years of investigation.

Application of 75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit, recorded maximum leaf area index being at par with 100% RDF (150:60:40 kg ha^{-1}) but significantly higher value of leaf area index at all stage of crop growth except 30 DAS during both the years of experimentation. This might be due to application of mixed fertilizers like RDF, FYM and nano-urea to meet the plant requirement nutrients that cause the maximum leaf area index. Similar result was also reported by Gharde and Singh (2018) [6].

Among weed control practices, weed free, recorded the maximum leaf area index and being at par with Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) during both years of investigation but being significantly superior over rest of the weed control practices at all the stages of crop growth except at 30 DAS. Similar results were also reported by scientists Yaduraju and Mishra (2018) [16], and Tanwar *et al*. (2021) [15].

Dry matter accumulation (g m^{-2})

Nutrient management and weed control practices exhibited significant variation of dry matter accumulation at all stage of growth except at 30 DAS where the weed control practice was found non-significant in respective years 2022-23 and 2023-24 (Table-4).

Perusal of data summarized in Table: 4 revealed that dry matter accumulation of crop varied significantly due to nutrient management at all crop growth stages during 2022-23 and 2023-24. Application of 75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit recorded maximum dry matter accumulation (600.75, 614.93), (1001.26, 1024.88), and (1164.25, 1194.38) at 60, 90 DAS and at harvest, respectively and being at par with 100% RDF (150:60:40 kg ha^{-1}) during both year of investigation while significantly higher than rest of treatments. The application of combined fertilizers (RDF, FYM and nano-urea) in treatment 75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit. cause the maximum dry matter accumulation. Similar results were reported by Pal *et al.* (2012) [9], Saquib *et al.* (2012) [12].

Table 1: Effect of weed and nutrient management on plant height (cm) at different stages of crop growth of wheat

Treatment		plant height (cm)							
		30 DAS		60 DAS		90 DAS		At harvest	
		2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
A. Main plot (Nutrient Management)									
F_1	100% RDF (150:60:40 kg ha^{-1})	25.08	25.45	66.33	67.15	85.70	87.08	86.37	87.30
F_2	75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit	25.82	26.22	68.88	69.75	89.07	90.25	89.52	90.45
F_3	50% RDF + 15 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit	25.37	25.17	61.60	62.33	79.65	80.77	80.17	81.02
	SEm±	0.475	0.489	1.200	1.249	1.523	1.632	1.563	1.592
	C.D. at 5%	NS	NS	4.713	4.906	5.978	6.409	6.136	6.249
B. Sub plot (Weed Management)									
W_1	Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1})	25.47	25.87	67.70	68.13	86.50	87.80	87.10	88.03
W_2	Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1})	25.63	26.03	68.30	69.03	88.07	89.40	88.77	89.70
W_3	Sulfosulfuron + Carfentrazone (25 + 20 g a.i. ha^{-1})	24.93	25.33	64.87	65.77	84.23	85.40	84.70	85.60
W_4	Clodinofop + Carfentrazone (60 + 20 g a.i. ha^{-1})	24.73	25.10	63.33	64.23	82.23	83.40	82.73	83.60
W_5	Weed free (two hand weeding at 20 and 45 DAS)	26.07	26.47	69.00	69.93	89.27	90.53	89.80	90.73
W_6	Weedy check	25.70	24.87	60.43	61.37	78.53	79.67	79.00	79.87
	SEm±	0.549	0.663	1.405	1.433	1.811	1.853	1.828	1.876
	C.D. at 5%	NS	NS	4.057	4.140	5.231	5.351	5.279	5.418

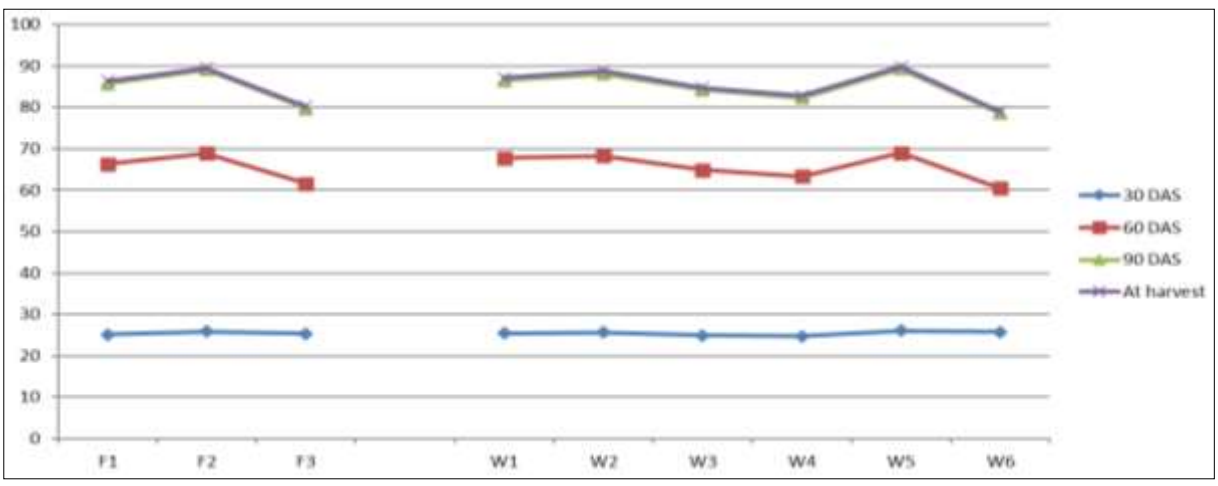

Fig 1a: Effect of weed and nutrient management on plant height (cm) at different stages of crop growth of wheat during 2022-23

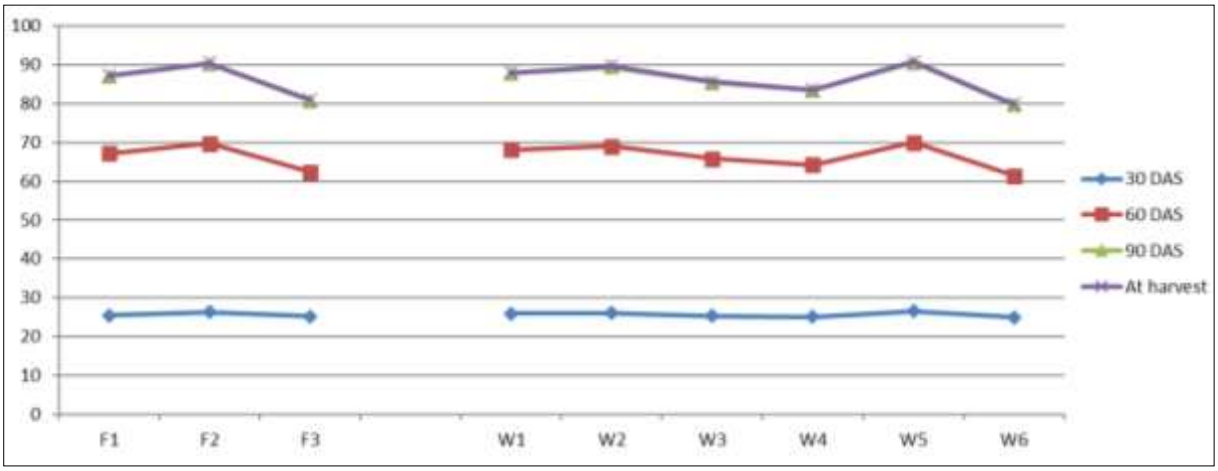

Fig 1b: Effect of weed and nutrient management on plant height (cm) at different stages of crop growth of wheat during 2023-24

Table 2: Effect of weed and nutrient management on number of tillers (m^{-2}) at different stages of crop growth of wheat:

Treatment		Number of tillers (m^{-2})							
		30 DAS		60 DAS		90 DAS		At harvest	
		2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
A. Main plot (Nutrient Management)									
F_1	100% RDF (150:60:40 kg ha^{-1})	208.97	212.07	286.53	288.37	301.45	303.27	295.52	297.60
F_2	75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit	215.20	218.42	294.53	296.37	309.85	311.72	303.78	305.88
F_3	50% RDF + 15 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit	206.67	209.68	263.15	264.92	276.78	278.45	271.33	273.23
	SEm±	4.547	4.070	5.376	5.415	5.505	6.089	5.291	5.628
	C.D. at 5%	NS	NS	21.108	21.263	21.616	23.909	20.775	22.098
B. Sub plot (Weed Management)									
W_1	Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1})	212.37	215.47	289.23	291.34	304.47	306.30	298.50	300.60
W_2	Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1})	213.63	216.87	294.23	296.10	308.57	310.40	302.47	304.60
W_3	Sulfosulfuron + Carfentrazone (25 + 20 g a.i. ha^{-1})	207.97	210.97	284.20	285.19	299.17	300.97	293.30	295.33
W_4	Clodinofop + Carfentrazone (60 + 20 g a.i. ha^{-1})	206.07	209.17	282.23	284.21	297.10	298.90	291.27	293.30
W_5	Weed free (two hand weeding at 20 and 45 DAS)	217.33	220.50	296.63	297.61	312.23	314.13	306.10	308.23
W_6	Weedy check	204.30	207.37	241.90	245.90	254.63	256.17	249.63	251.37
	SEm±	5.848	5.523	6.147	7.479	6.417	8.678	6.275	7.773
	C.D. at 5%	NS	NS	17.755	21.602	18.533	25.065	18.124	22.450

Table 3: Effect of weed and nutrient management on leaf area index at different stages of crop growth of wheat:

Treatment		Leaf area index					
		30 DAS		60 DAS		90 DAS	
		2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
A. Main plot (Nutrient Management)							
F_1	100% RDF (150:60:40 kg ha^{-1})	1.25	1.27	4.05	4.09	4.14	4.20
F_2	75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit	1.29	1.31	4.18	4.24	4.27	4.36
F_3	50% RDF + 15 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit	1.23	1.25	3.73	3.80	3.82	3.87
	SEm±	0.023	0.026	0.085	0.077	0.077	0.079
	C.D. at 5%	NS	NS	0.332	0.301	0.301	0.309
B. Sub plot (Weed Management)							
W_1	Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1})	1.27	1.29	4.04	4.10	4.15	4.21
W_2	Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1})	1.27	1.29	4.20	4.24	4.25	4.32
W_3	Sulfosulfuron + Carfentrazone (25 + 20 g a.i. ha^{-1})	1.24	1.26	3.93	3.98	4.04	4.10
W_4	Clodinofop + Carfentrazone (60 + 20 g a.i. ha^{-1})	1.23	1.25	3.83	3.89	3.94	4.00
W_5	Weed free (two hand weeding at 20 and 45 DAS)	1.30	1.32	4.25	4.34	4.31	4.41
W_6	Weedy check	1.22	1.24	3.66	3.72	3.76	3.82
	SEm±	0.027	0.036	0.112	0.105	0.088	0.108
	C.D. at 5%	NS	NS	0.324	0.304	0.254	0.311

Table 4: Effect of weed and nutrient management on dry matter accumulation (g m^{-2}) at different stages of crop growth of wheat:

Treatment		Dry matter accumulation (g m^{-2})							
		30 DAS		60 DAS		90 DAS		At harvest	
		2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
A. Main plot (Nutrient Management)									
F_1	100% RDF (150:60:40 kg ha^{-1})	80.40	81.59	588.35	594.98	980.59	991.64	1140.22	1153.07
F_2	75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit	82.80	84.03	600.75	614.93	1001.26	1024.88	1164.25	1194.38
F_3	50% RDF + 15 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit	79.50	80.68	514.10	521.00	856.83	868.33	996.32	1009.35
	SEm±	1.478	1.667	10.012	10.987	17.060	19.388	23.315	21.288
	C.D. at 5%	NS	NS	39.312	43.139	66.986	76.125	91.546	83.587
B. Sub plot (Weed Management)									
W_1	Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1})	81.70	82.91	616.67	625.67	1027.79	1042.78	1195.10	1214.20
W_2	Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1})	82.20	83.42	627.71	636.61	1046.19	1061.01	1216.50	1236.40
W_3	Sulfosulfuron + Carfentrazone (25 + 20 g a.i. ha^{-1})	80.00	81.18	554.68	564.04	924.47	940.07	1074.97	1093.10
W_4	Clodinofop + Carfentrazone (60 + 20 g a.i. ha^{-1})	79.30	80.48	522.73	532.22	871.21	887.03	1013.03	1031.43
W_5	Weed free (two hand weeding at 20 and 45 DAS)	83.60	84.84	639.67	648.53	1066.11	1080.88	1239.67	1257.17
W_6	Weedy check	78.60	79.77	444.95	454.75	741.58	757.92	862.30	881.30
	SEm±	1.743	2.342	12.173	15.082	20.360	27.808	31.703	29.225
	C.D. at 5%	NS	NS	35.157	43.560	58.805	80.315	91.563	84.408

Summary

Basis on the results, 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit. recorded maximum value of plant height (cm), number of tillers (m^{-2}), LAI and dry matter accumulation, being at par with 100% RDF (150:60:40 kg ha^{-1}), which significantly higher than 50% RDF + 15 t ha^{-1}FYM + one spray of nano-urea @ 4 ml/lit. during both year of investigations. Among herbicidal treatments Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}), recorded maximum values of growth parameters, being at par with Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1}) whereas both herbicidal treatments comparable with weed free which significantly superior than rest of the weed control practices during both years of investigations.

Fig 2: Recording of Plant height in experimental field

Conclusion

On the basis of experiment, it can be concluded that application of 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4 ml/lit with the spraying of herbicides Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) found superior for increasing the plant height, number of tillers, dry matter accumulation and leaf area index of wheat.

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