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Impacts of *Calotropis* and *Azadirachta* Green Leaf Manure and Bio Decomposer on Growth and Yield of Lentil

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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

A field experiment was conducted to study the effect of integrated nitrogen management on growth and yield of lentil (*Lens culinaris* Madik.) at Agronomic Research Farm, R. S. M. (P. G.) College, Dhampur (Bijnor) during the *Rabi* season 2023. The experiment was laid down in a randomized block design having seven treatments i.e. Control, RDN (80% N) + *Calotropis gigantea* green leaf

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manuring (GLM) (20% N), RDN (80% N) + Neem GLM (20% N), RDN (80% N) + *Calotropis gigantea* GLM (20% N) + waste decomposer soil application (WDSA), RDN (80% N) + Neem GLM (20% N) + WDSA, RDN (80% N) + *Calotropis gigantea* leaf Cutting (20% N) dipped in waste decomposer (WD) solution, RDN (80% N) + Neem leaf Cutting (20% N) dipped in WD solution) and replicated three times. Significant increase in growth characters (plant height and fresh weight), yield contributing character (number of pods) and yields (grain yield and straw yield) was observed with integrated nitrogen management over control. Moreover, among integrated nitrogen management treatments, the integration of RDN (80% N) + Neem leaf Cutting (20% N) dipped in WD solution) came out to be best for growth parameters, yield attribute and yield. It is concluded from the experiment that RDN (80% N) + Neem leaf Cutting (20% N) dipped in WD solution is the most effective treatment for enhancing lentil production under Dhampur conditions. Recommendation of this findings would allow Lentil farmers to save money which otherwise would be spent on nitrogenous fertilizer.

Keywords: Waste decomposer; Calotropis gigantea; neem leaves; integrated nitrogen management.

1. INTRODUCTION

Lentil (*Lens culinaris* Medic.) is one of the oldest annual grain legumes consumed and cultivated in the world. Originating from South Western Asia as early as 6000 B.C. Lentil is rich in proteins and contains high concentrations of essential amino acids like isoleucine and lysine, as well as other nutrients like dietary fiber, folate, vitamin B1, and minerals (Rozan et al. 2001). Lentil is widely consumed in various parts of the world as loaves, soups, pies, curries etc., especially in vegetarian cultures. It is also an important source of dietary protein in the Mediterranean and South Asian regions. Lentil is a cool season pulse crop and is also relatively tolerant to drought. It is the second most important cool season food legume after chickpea. Being grown for over 8,000 years (Dhuppar et al. 2012). The total cultivated area in the world as around 5.58 million hectares producing 5.61 million tonnes of seeds with an average production of 1004.3 kg ha^{-1} (FAOSTAT 2023). The total cultivated area of lentil in India is around 1.45 million hectares which produced a total of 1.45 million tonnes seed yield with a productivity of 1001 kg ha^{-1}. In Uttar Pradesh lentil cultivation done on 0.47 million hectare area which produce 0.47 million tonnes seed (DAC&FW 2021).

Green leaf manures (GLMs) are organic manures made from leaves collected from all available sources and used to supply essential plant nutrients to the soil and increase soil fertility in a healthy manner (Raza, 2023).

Calotropis spp. grows as a weed in many areas of India, but it is also purposefully planted. The plant's root system has been shown to break up and cultivate cropland. It is useful green leaf manure and will be plowed in before the "real" crop is sown. *Calotropis spp.* GLM improves soils nutrients and moisture binding of soil. According to (Souza et al. 2017) the cultivation in autumn-winter promoted greater accumulations of green and dry mass in the coriander shoot fertilized with *Calotropis spp*. The best productive performance of coriander was observed with the addition of *Calotropis spp.* to the soil in the amounts of 12.2 t ha^{-1} (spring) and 8.8 t ha^{-1} (autumn-winter).

Neem leaf manure (NLM) is gaining popularity due to being environmental friendly and could as well increase nitrogen and phosphorus content of the soil (Oyekunle and Abosede 2012). The leaves of the Neem plant used as green fertilizer and the conservation of crops after harvest. The Neem extract increases soil content of nitrogen, phosphorus and sulfur Phosphorus, Calcium and Nitrogen (Lokanadhan et al. 2012).

Decomposer hold promise against issue of residue burning and are available in the form of capsules or gel made by using efficient strains of microbes that accelerate the decomposition of crop residues at a much faster rate than its usual rate (Aakash et al. 2023). The microbes produce essential enzymes for the degradation process. By considering the importance of lentil and beneficial effect of green leaf manure, waste decomposer etc. the present study was carried out to achieve the following objectives: to study the influence of *Calotropis* and *Azadirachta* green leaf manure and bio decomposer on growth attributes; to assess the influence of *Calotropis* and *Azadirachta* green leaf manure and bio decomposer on yield attributes and yield.

2. MATERIALS AND METHODS

2.1 Experimental Site, Climatic Condition, Soil Property and Treatment Details

The experiment was conducted at Research Farm of R. S. M. (P.G.) College Dhampur, Bijnor (Uttar Pradesh), India during *Ravi* season (2022–23). The topography of field was uniform with gentle slope. Bijnor is situated in North-Western Plains agro-climatic zone in the Uttar Pradesh at an altitude of 225 m above mean sea level (MSL). It is located in the north-western corner of the Moradabad Division, the districts geographical coordinates span between approximately 29°2' and 29°58' North latitude, and 78°00' and 78°57' East longitude. The District's overall area is subject to minor fluctuations due to the unpredictable shifts of the Ganges and Ramganga rivers. This region enjoys tropical semi-arid type climate with an average annual rainfall of 964 mm, most of which is received during mid-June to middle of September. Bijnor district receives average 100-110 cm rainfall. The major rainfall received during month of June to September. The average temperature ranges between 10°C (during Dec. and Jan.) to 48°C (during May and June).

The soil was found to be slightly alkaline in reaction (7.26 pH) and relatively low in organic carbon (0.36%). In terms of electrical conductivity, the soil exhibited a value of 0.26 dSm^{-1}. On the other hand, the levels of available nutrients were as follows: The soil contained a moderate amount of available nitrogen, with a concentration of 185.0 kg ha^{-1}. Additionally, the soil exhibited medium levels of available phosphorus at 16.8 kg ha^{-1}, and a similar medium range of available potassium at 243 kg ha^{-1} (Table 1).

2.2 Crop Management

The recommended practices for raising crops encompass several essential steps. Preparatory tillage involves initial irrigation, known as "Palewa," administered in the experimental field to achieve optimal moisture conditions for seed germination. This was followed by plowing and cross-harrowing with a tractor-drawn plough and cultivator, respectively, to prepare the field for sowing. Levelling through planking ensures a suitable seed bed. Application of fertilizers like Urea, DAP (Di-ammonium phosphate), and muriate of potash provides essential nutrients at sowing, with a dosage of 20 kg of nitrogen (N), 40 kg of phosphorous pentoxide (P_2O_5), and 20 kg of potassium oxide (K_2O) per hectare (ha). Seed selection and treatment, such as using lentil variety L-4717 and treating seeds with *Rhizobium* culture @ 20 g kg^{-1} of seed, contribute to successful germination. Manual sowing was done in rows spaced 30 cm apart at a depth of 5 cm followed by irrigation management using a tube well. Weed control involved the application of pre-emergence herbicide, Pandimethalin @ 1.5 kg ha^{-1}, and hand weeding once at 25 days after sowing (DAS). Insect management included the application of Thiamethoxam @ 100 g ha^{-1} for aphid control. Harvesting was done manually with sickles when the stem and pods turn straw color or light brown, and the seed are hard rattle within the pod. Threshing and winnowing follow, separating seeds from pods and debris.

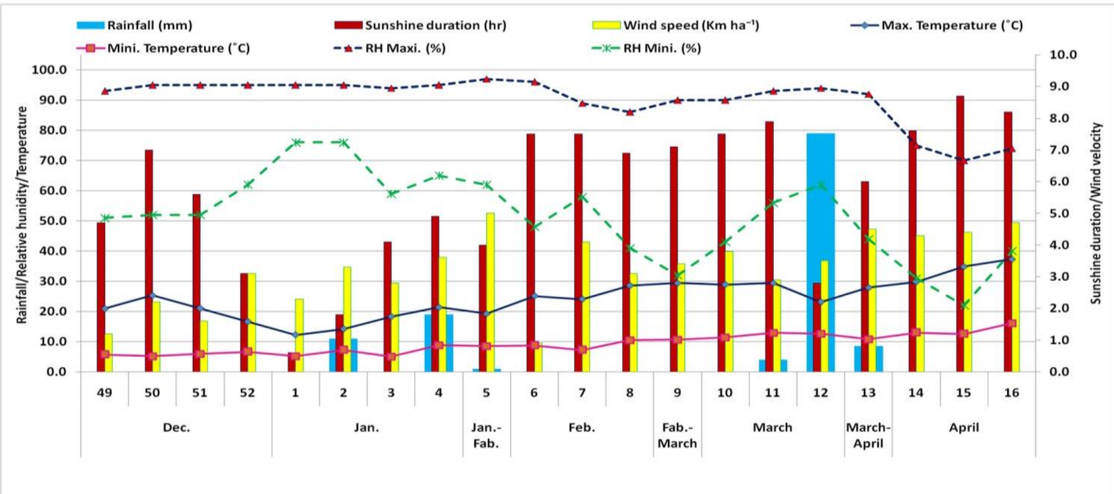

Fig. 1. Mean weekly meteorological observation during crop season

Table 1. Physico-chemical properties of the soil of the experimental field

Mechanical analysis values of soil			
S. No.	**Soil separates and textural class**	**Values (%)**	**Method of analysis**
1.	Sand	22.45%	Hydrometer method
2.	Silt	51.32%	(Bouyoucos 1962)
3.	Clay	21.84%	
4.	Textural class	Silty loam	Triangular method (Lyon et al. 1952)
Chemical analysis values of soil			
S. No.	**Particulars**	**Values**	**Method of analysis**
1.	Soil reaction (pH) (1:2 soil water ratio)	7.26	Glass electrode pH meters (Jackson 1967)
2.	EC (dSm^{-1})	0.26	Electrical conductivity bridge meter (Richard 1954)
3.	Organic carbon (%)	0.36	Walkley and Black rapid titration method (Walkley and Black 1934)
4.	Available nitrogen (kg ha^{-1})	185.0	Alkaline potassium permagnate method (Subbiah and Asija 1956)
5.	Available phosphorus (kg ha^{-1})	16.8	Olsen's method (Olsen et al. 1954)
6.	Available potassium (kg ha^{-1})	243.0	Flame emission spectrophotometer (Jackson 1973)

Table 2. Treatment details

S. No.	**Treatment**	**Symbol**
1.	Control	T_1
2.	RDN (80%) + *Calotropis* GLM (RDN 20%)	T_2
3.	RDN (80%) + Neem GLM (RDN 20%)	T_3
4.	RDN (80%) + *Calotropis* GLM (RDN 20%) + WDSA	T_4
5.	RDN (80%) + Neem GLM (RDN 20%) + WDSA	T_5
6.	RDN (80%) + *Calotropis* GLM (RDN 20%) Leaf cutting dipped in WDS	T_6
7.	RDN (80%) + Neem GLM (RDN 20%) Leaf cutting dipped in WDS	T_7

Note: RDN = Recommended dose of nitrogen, GLM = Green leaf manure, WDSA = Waste decomposer soil application @ 2500 ltr ha^{-1}, WDS = Waste decomposer solution, Nitrogen content in Calotropis gigantea GLM was 2.06%, Nitrogen content in Neem GLM was 2.83%

2.3 Sampling and Observation

In each net plot, five plants were selected randomly and tagged for periodic observations. The height was recorded 20, 40 and 60 DAS in the net plots. It was measured from ground level to the base of the last unfolded leaf at the top of the main stem. The mean plant height of these five tagged plants was computed with the help of a meter scale in cm and used for statistical analysis. The fresh weight of crop was recorded by destructive method. Five plants were selected at random in each plot from boarder rows for recording fresh weight accumulation at 20, 40 and 60 DAS. Plants were cut from the ground layer, and immediately weighted by using electronic balance in gram (g). After weighing the fresh samples, plants were sun-dried and then dried in the oven at 68°C ± 2°C till constant weight was obtained for recording dry matter accumulation. Dried samples were weighed separately by using electronic balance. Dry matter was measured as g $plant^{-1}$. Pods of 5 plants were randomly selected at maturity from each treatment and counted and average number of pods $plant^{-1}$ was calculated.

2.4 Statistical Analysis

The data obtained from growth and yield attribute parameters were subjected to analysis of variance (ANOVA) using Statistical Tool for Agricultural Research (STAR) software (version STAR 2.0.1, IRRI, Los Baños, Philippines), while the significance of differences between treatment mean values was determined using the LSD (Least significant difference) test at 5% and 1% levels.

3. RESULTS AND DISCUSSION

As shown in results lentil growth and yield parameters were significant ($p \leq 0.05$) affected by *Calotropis* and *Azadirachta* green leaf manure and bio decomposer.

3.1 Growth Parameters

Data pertaining to the effect of *Calotropis* and *Azadirachta* green leaf manure and bio decomposer on plant height at 20, 40 and 60 DAS are given in Table 3. The plant height of lentil varied significantly with integrated nitrogen management practices at all the observed stages of crop growth except 20 DAS during the experimentation. The initial growth of lentil crop is slow, so plants were not able to utilized applied inputs effectively, that is the reason behind the no significant response of applied treatment at 20 DAS. At 40 DAS, maximum plant height was recorded under the application of RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS (T_7) which was significantly superior over rest of the treatments. At 60 DAS, the tallest plant was noted in treatment having RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS (T_7) which was at par with RDN (80%) + *Calotropis* GLM (20%) Leaf cutting dipped in WDS (T_6) but found significantly better to leftover treatments. It might be due to the quick supply of nitrogen through inorganic fertilizers and fast mineralization of neem leaf in the soil by effective microorganism present in the decomposer solution (Hussain et al. 2011) also conducted a field experiment on black gram and reported that plant height increased significantly with nitrogen applied at the rate of 30 kg ha^{-1}.

Data on fresh weight plant^{-1} shown in Table 4 as impacted by different treatments at various growth phases. As the crop grew older, the fresh weight plant^{-1} increased continuously until it reached maturity. The data concerning to fresh weight showed significant effect at 20, 40 and 60 DAS stage under *Calotropis* and *Azadirachta* green leaf manure and bio decomposer. At 20 DAS, application of RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS (T_7) resulted in maximum fresh weight (0.07 g plant^{-1}) which was statistically equal to rest of the treatment except control (T_1). The better response of T_7 might be due to fulfillment of balanced nitrogen requirement of plant at their actively nitrogen consuming phase, the similar result also reported by (Muhammad et al. 2023) who noted that nitrogen application @ 30 kg ha^{-1} increased shoot fresh weight. At 40 DAS, the highest fresh weight plant^{-1} was recorded in RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS (T_7), which was at par with RDN (80%) + *Calotropis* GLM (20%) Leaf cutting dipped in WDS (T_6) but found statistically superior to leftover treatment. At 60 DAS, the highest fresh weight plant^{-1} was recorded in RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS (T_7), which was at par RDN (80%) + *Calotropis* GLM (20%) Leaf cutting dipped in WDS (T_6) but found statistically superior to other treatment (Chouhan 2011) highlighted the significance of organic inputs in combination with synthetic sources of nutrition in lentil production and concluded that integrated nitrogen management having 20 kg N ha^{-1} + FYM @ 5 t ha^{-1} significantly increased total plant biomass up to maximum over the individual use of chemical fertilizer or organic source.

3.2 Yield Attributes

The results regarding effect of *Calotropis* and *Azadirachta* green leaf manure and Bio decomposer on number of pods plant^{-1} graphically presented in Fig. 2. According to the result, all treatments were found significantly superior over control (T_1). Among the different treatments, the maximum numbers of pods were observed in RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS (T_7) in followed by RDN (80%) + *Calotropis* GLM (20%) Leaf cutting dipped in WDS (T_6), RDN (80%) + Neem GLM (20%) + WDSA (T_5), RDN (80%) + *Calotropis* GLM (20%) + WDSA (T_4), RDN (80%) + Neem GLM (20%) (T_3), and RDN (80%) + *Calotropis* GLM (20%) (T_2), these values were 61.0, 60.3, 58.7, 56.0, 54.3, and 53.0, respectively. The minimum number of pods plant^{-1} was recorded in control (51.7).

3.3 Yield

The results regarding impact of *Calotropis* and *Azadirachta* green leaf manure and Bio decomposer on grain yield presented in Table 5. According to the result, all treatments were found significantly superior over control in increasing grain yield.

Table 3. Influence of *Calotropis* and *Azadirachta* green leaf manure and Bio decomposer on plant height

Treatment		Plant height (cm)		
		20 DAS	40 DAS	60 DAS
T_1	Control	2.5	3.7c	6.4c
T_2	RDN (80%) + *Calotropis* GLM (RDN 20%)	3.0	5.0b	8.2b
T_3	RDN (80%) + Neem GLM (RDN 20%)	3.0	5.2b	8.4b
T_4	RDN (80%) + *Calotropis* GLM (RDN 20%) + WDSA	3.2	5.0b	8.4b
T_5	RDN (80%) + Neem GLM (RDN 20%) + WDSA	3.5	4.8b	8.8b
T_6	RDN (80%) + *Calotropis* GLM (RDN 20%) Leaf cutting dipped in WDS	2.8	5.1b	11.1a
T_7	RDN (80%) + Neem GLM (RDN 20%) Leaf cutting dipped in WDS	3.0	6.5a	11.4a
SEm±		0.2	0.3	0.5
CD (P≤0.05)		NS	1.0	1.5

Note: RDN = Recommended dose of nitrogen, GLM = Green leaf manure, WDSA = Waste decomposer soil application @ 2500 ltr ha^{-1}, WDS = Waste decomposer solution

Table 4. Influence of *Calotropis* and *Azadirachta* green leaf manure and Bio decomposer on fresh weight

Treatment		Fresh weight (g plant^{-1})		
		20 DAS	40 DAS	60 DAS
T_1	Control	0.05b	0.18c	3.32d
T_2	RDN (80%) + *Calotropis* GLM (RDN 20%)	0.07a	0.21c	3.82cd
T_3	RDN (80%) + Neem GLM (RDN 20%)	0.07a	0.21c	3.99bc
T_4	RDN (80%) + *Calotropis* GLM (RDN 20%) + WDSA	0.06a	0.27b	4.39bc
T_5	RDN (80%) + Neem GLM (RDN 20%) + WDSA	0.07a	0.28b	4.57b
T_6	RDN (80%) + *Calotropis* GLM (RDN 20%) Leaf cutting dipped in WDS	0.07a	0.32a	5.29a
T_7	RDN (80%) + Neem GLM (RDN 20%) Leaf cutting dipped in WDS	0.07a	0.35a	5.66a
SEm±		0.003	0.01	0.21
CD (P≤0.05)		0.01	0.04	0.65

Note: RDN = Recommended dose of nitrogen, GLM = Green leaf manure, WDSA = Waste decomposer soil application @ 2500 ltr ha^{-1}, WDS = Waste decomposer solution, For supply of 20% N 196.17 kg Calotropis gigantea GLM was used, For supply of 20% N 141.32 kg Neem GLM was used

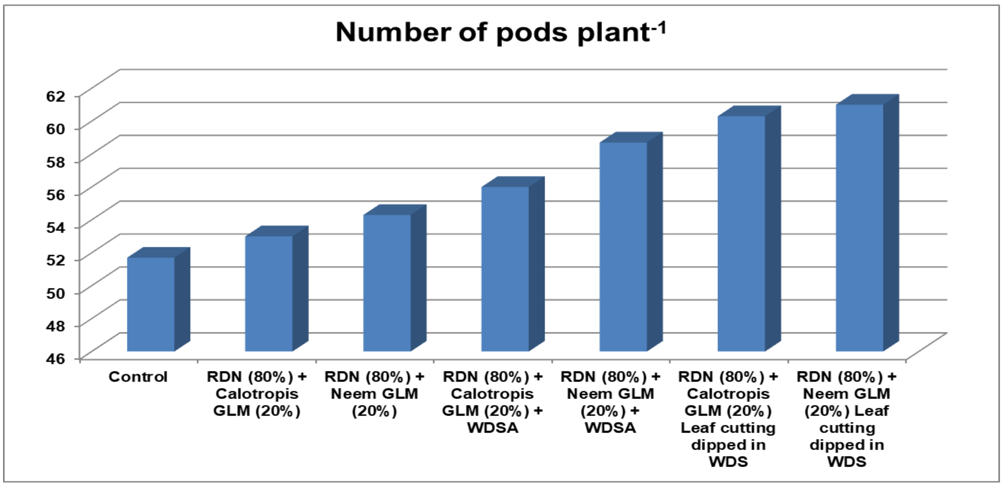

Fig. 2. Number of pods as influenced by *Calotropis* and *Azadirachta* green leaf manure and Bio decomposer

Table 5. Influence of *Calotropis* and *Azadirachta* green leaf manure and Bio decomposer on grain yield

Treatment		Yield (q ha^{-1})
T_1	Control	9.32d
T_2	RDN (80%) + *Calotropis* GLM (RDN 20%)	10.17d
T_3	RDN (80%) + Neem GLM (RDN 20%)	11.17c
T_4	RDN (80%) + *Calotropis* GLM (RDN 20%) + WDSA	12.26b
T_5	RDN (80%) + Neem GLM (RDN 20%) + WDSA	12.33b
T_6	RDN (80%) + *Calotropis* GLM (RDN 20%) Leaf cutting dipped in WDS	13.68a
T_7	RDN (80%) + Neem GLM (RDN 20%) Leaf cutting dipped in WDS	14.29a
SEm±		0.31
CD (P≤0.05)		0.97

Note: RDN = Recommended dose of nitrogen, GLM = Green leaf manure, WDSA = Waste decomposer soil application @ 2500 ltr ha^{-1}, WDS = Waste decomposer solution, For supply of 20% N 196.17 kg Calotropis gigantea GLM was used, For supply of 20% N 141.32 kg Neem GLM was used

Table 6. Influence of *Calotropis* and *Azadirachta* green leaf manure and Bio decomposer on straw yield

Treatment		Straw yield (q ha^{-1})
T_1	Control	12.8e
T_2	RDN (80%) + *Calotropis* GLM (RDN 20%)	14.4d
T_3	RDN (80%) + Neem GLM (RDN 20%)	15.1d
T_4	RDN (80%) + *Calotropis* GLM (RDN 20%) + WDSA	15.7cd
T_5	RDN (80%) + Neem GLM (RDN 20%) + WDSA	16.6bc
T_6	RDN (80%) + *Calotropis* GLM (RDN 20%) Leaf cutting dipped in WDS	17.6ab
T_7	RDN (80%) + Neem GLM (RDN 20%) Leaf cutting dipped in WDS	18.5a
SEm±		0.5
CD (P≤0.05)		1.5

Note: RDN = Recommended dose of nitrogen, GLM = Green leaf manure, WDSA = Waste decomposer soil application @ 2500 ltr ha^{-1}, WDS = Waste decomposer solution, For supply of 20% N 196.17 kg Calotropis gigantea GLM was used, For supply of 20% N 141.32 kg Neem GLM was used

Among the different treatments, the highest grain yield observed under the application of RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS (T_7) (14.29 q) which was statistically superior to remaining treatments except the application of RDN (80%) + *Calotropis* GLM (20%) Leaf cutting dipped in WDS (T_6) (13.68 q). Furthermore, RDN (80%) + Neem GLM (20%) + WDSA (T_5) (12.33 q), RDN (80%) + *Calotropis* GLM (20%) + WDSA (T_4) (12.26 q), RDN (80%) + Neem GLM (20%) (T_3) (11.17 q), and RDN (80%) + *Calotropis* GLM (20%) (T_2) (10.17 q) produced substantially higher grain yield than control (T_1) (9.32 q). The minimum grain yield was recorded in control.

The results regarding impact of *Calotropis* and *Azadirachta* green leaf manure and Bio decomposer on straw yield presented in Table 6. According to the experimental findings, all treatments were found significantly superior over control in increasing grain yield. Among the different treatments, the highest straw yield observed under the application of RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS (T_7) (18.5 q ha^1) which was significantly at par with RDN (80%) + *Calotropis* GLM (20%) Leaf cutting dipped in WDS (T_6) (17.6 q ha^1). Furthermore, the application of, RDN (80%) + Neem GLM (20%) + WDSA (T_5) (16.60 q ha^{-1}), RDN (80%) + *Calotropis* GLM (20%) + WDSA (T_4) (15.70 q ha^{-1}), RDN (80%) + Neem GLM (20%) (T_3) (15.1 q ha^{-1}), and RDN (80%) + *Calotropis* GLM (20%) (T_2) (14.4 q ha^{-1}) produced substantially higher straw yield than control (T_1) (12.8 q ha^{-1}) (Aggarwal and Ram 2011).

The similar result also recorded by Aggarwal and Ram (2011) that proved the significance of integrated use of organic and inorganic fertilizers towards improvement in the yield attributing character and yield of lentil. They advocated enhanced pods (46.3 $plant^{-1}$) and biological yield (2876 kg ha^{-1}) with application of FYM @ 15 t ha^{-1} + RDN (12.5 kg N ha^{-1}) (Dekhane et al. 2012) also reported that starter N applied at a rate of 15 kg ha^{-1} increased seed yield of lentil by 13% (Jan 2004) also reported that 20 kg N ha^{-1} significantly improved number of pods plant^{-1}, number of seeds pod^{-1} and 1000-seed weight of lentil.

4. CONCLUSION

Plant height, fresh weight, yield and yield characters were recorded highest in application of RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS. On the basis of result, it is concluded that the application of RDN (80%) + Neem GLM (20%) Leaf cutting dipped in WDS found most profitable as compared to other treatments under Dhampur, Bijnor (Uttar Pradesh) condition.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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