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RESEARCH ARTICLE

Effect of Dates of Sowing and Nutrient Levels on Yield and Yield Attributes of Sunn hemp (*Crotalaria juncea*)

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ABSTRACT

A field trial was done to determine the optimum sowing date and nutrient levels on yield and yield parameters of Sunn hemp during summer (January - May) 2022 at Eastern Block Farm, Tamil Nadu Agricultural University, Coimbatore. The field trial was laid out with 12 treatments in a split-plot design and every treatment was replicated thrice. Three sowing dates (the last week of January, the first and second weeks of February) were performed in the main plot, and four different nutrient levels (20:40:20 kg NPK ha^{-1}, 25:50:25 kg NPK ha^{-1}, 30:60:30 kg NPK ha^{-1} and 12.5 tons FYM ha^{-1}) in the subplot. Yield attributes such as the number of pods per plant, Seeds per pod, seed index, pod setting percentile, pod filling percentile, and seed yield were noted. Sunn hemp sown during the second week of February along with 30:60:30 kg NPK ha^{-1} was noted with higher yield attributes and seed yield of Sunn hemp.

Keywords: *Sunn hemp; Date of sowing; Nutrient level; Green manure; Seed production*

1. INTRODUCTION

Sunn hemp (*Crotalaria juncea*) is one of the important tropical legumes for its 3F activity (fertilizer, fodder, and fiber) and is used as a cover crop (Eberle and Shortnacy, 2021). It is contrarily called Indian hemp, which originated from India. It belongs to the family Fabaceae (Kavin *et al*., 2018).

India is the leading producer of Indian hemp which is under an area of 10,300 ha with a production of 43600 bales and productivity of 715 kg ha^{-1} followed by Bangladesh and Brazil (IndiaStat, 2024). In India, Sunn hemp was cultivated in the states of West Bengal, Orissa, Chhattisgarh, Bihar, Rajasthan, Maharashtra, Uttar Pradesh, and Madhya Pradesh (Pon Arasan *et al*., 2022).

It provides 50-75:15-20:40-65 kg NPK ha^{-1} through green manure. Additionally, it fixes 50-60 kg N using root nodules (Kavin *et al*., 2018). It improves water holding capacity, and soil texture and neutralizes the soil salinity. Apart from these, it performs as a cover crop, checks soil erosion, and manages root-knot nematode (Pon Arasan *et al*., 2022).

Under the sole cropping system, soil fertility is reduced more rapidly. The increased cost of inorganic fertilizers and poor soil fertility were the main reasons for practicing green manuring activity (Sandhya Rani *et al*., 2022). Sunn hemp cultivation area was reduced from 1,64,900 ha (1970) to 11,000 ha (2021) in the past five decades (IndiaStat, 2024). Non-availability of good quality seeds is the major concern in area reduction under Sunn hemp cultivation. Improper agronomic practices led to poor Sunn hemp seed production. There is a need to optimize the agronomic practices *i.e*. sowing time, nutrient management, weed management, spacing, and irrigation management. Considering this, the field trial was carried out to find the optimum sowing date and nutrient level for higher seed yield of Sunn hemp.

2. MATERIAL AND METHODS

2.1. Experimental site and soil analysis

The field trial was conducted during the Summer of 2022 at Eastern Block Farm,

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Department of Agronomy, Tamil Nadu Agricultural University (TNAU), Coimbatore. The research field was sited at 11˚1'6" N latitude and 76˚58'21" E longitude with an elevation of 426.7 m above MSL in the Western zone of Tamil Nadu. The field was sandy clay loam with pH and electrical conductivity of 8.91 and 0.28 dSm^{-1}, respectively. The initial available nutrient content of the soil was 179 N kg ha^{-1} (Low), 27.2 P_2O_5 kg ha^{-1} (High), and 806 kg K kg ha^{-1} (High). The organic carbon content of the soil was 0.49%.

2.2. Experiment details

The experimental design was laid out in a split-plot design with three main plots and four subplots and replicated thrice. Several sowing dates were considered as the main plot and nutrient levels in subplots. Main plot treatments are D_1 - sowing during January 4th week, D_2 - sowing during February 1st week, D_3 - sowing during February 2nd week and subplot treatments are N_1 - 20:40:20 kg NPK ha^{-1}, N_2 - 25:50:25 kg NPK ha^{-1}, N_3 - 30:60:30 kg NPK ha^{-1} and N_4 - 12.5 tons of FYM ha^{-1}.

2.3. Weather conditions prevailed during the cropping period

During the entire field experiment, an average maximum and minimum temperature of 36.3˚C and 24.4 ˚C with an average wind speed of 5.1 km hr^{-1} prevailed. The total amount of rainfall received over the cropping period was 57.9 mm.

2.4. Agronomic practices

Local landrace seed was obtained from the Central Farm of TNAU for this study. After primary and secondary tillage, ridges and furrows were formed at 60 cm intervals. Seeds were sown on both sides of the ridges at 30 x 10 cm spacing. The crop was raised fully under irrigated conditions. Based on the treatments, the entire amount of farmyard manure (FYM), phosphorous (P), and potassium (K) were applied as basal dose, whereas nitrogen (N) was applied in three doses (50% N as basal, 25% N at 30 DAS and 25% N at 60 DAS). Urea, single super phosphate, and muriate of potash were used as sources of N, P, and K, respectively. All the crop production practices were followed as per the recommendations of the TNAU Crop Production Guide - Agriculture, 2020.

2.5. Biometric observation and statistical analysis

In the net-plot area, randomly five plants were selected and tagged to record observations, and data were collected. A total number of pods were counted and averaged from five tagged plants. Total seeds were counted from twenty pods and averaged into number of seeds $capsule^{-1}$. Pod filling percentage (Eqn. 1) was worked out with the number of seeds and scars presented in a single pod.

$$\text{Pod filling percentage} = \frac{\text{Total number of seeds pod}^{-1}}{\text{Total seeds pod}^{-1} + \text{scars present in the pod}} \times 100$$

(Eqn. 1)

Pod setting percentage (Eqn. 2) worked out with the total number of pods to the number of flowers in five tagged plants.

$$\text{Pod setting percentage} = \frac{\text{Total number of pods plant}^{-1}}{\text{Total number of flowers plant}^{-1}} \times 100$$

(Eqn. 2)

After threshing and cleaning, seeds from the net plot were weighed and given as seed yield. A hundred seeds were counted and weighed as seed index. Stalk yield was computed by weighing the leftover stalks after the threshing of pods. The data of different parameters were statistically analysed by the ANOVA method suggested by Gomez and Gomez (2010).

3. RESULTS AND DISCUSSION

3.1. Number of pods $plant^{-1}$

The effect of dates of sowing and nutrient levels on the number of pods $plant^{-1}$ is listed in Table 1. Sunn hemp sown in the last week of January recorded significantly a greater number of pods $plant^{-1}$ (18.7). February first week sown crop has recorded the smaller number of pods $plant^{-1}$ (14.5). A reduction of 22.5 percent of pods was recorded in February's first week sown crop over January's last week sown Sunn hemp. Excessive rain with heavy wind during the flowering stage of February's first week sown crop attributed lower number of pods $plant^{-1}$. An increase in cumulative heat units (CHU) has negatively correlated with the number of pods in Sunn hemp (Figure 1). Higher growing degree day accumulation is negatively correlated with yield attributes of Sunn hemp (Subrahmaniyan *et al*., 2021). Early sown crops had enough duration for growth and development (Ahmad *et al*., 2021).

Application of nutrients @ 30:60:30 kg NPK ha^{-1} recorded a higher number of pods $plant^{-1}$ (18.5) than

12.5 t FYM ha^{-1} (14.8) applied plot. Application of high levels of nutrients led to greater absorption and translocation of nutrients, which may produce more pods $plant^{-1}$ (Kavin *et al*., 2018). Sarika *et al*., (2022) confirmed similar findings in soybean.

Sunn hemp sown during January last week along with 25:50:25 kg NPK ha^{-1} produced a greater number of pods $plant^{-1}$ (21.0), which is on par (20.2) with January last week's sown crop with the nutrient level of 30:60:30 kg NPK ha^{-1}.

3.2. Seeds pod^{-1}

The effect of dates of sowing and nutrient levels on the number of seeds pod^{-1} is listed in Table 1. January Last week's sown crop resulted in a greater seeds pod^{-1} (10.15), which was on par (9.26) with the crop sown in the first week of February. Crop sown during the second week of February registered fewer seeds pod^{-1} (8.94). Cumulative heat units had a negative correlation with the number of seeds pod^{-1}. A similar result was noticed by Kavin *et al.* (2018). Earlier sowing date has enough time for seed filling, which may result in more seeds pod^{-1}. Different nutrient levels were unaffected the number of seeds pod^{-1}.

3.3. Seed Index

The effect of dates of sowing and nutrient levels on seed index is listed in Table 1. The seed index of Sunn hemp was statistically non-significant among different dates of sowing, nutrient level, and interaction effect.

3.4. Pod setting percentage

The effect of dates of sowing and nutrient levels on pod setting percentage is listed in Table 2. Sunn hemp sown during the last week of January registered with more pod setting percentage (40.61 %). Crop sown during the second week of February was noticed with a lower pod setting percentage (29.75 %). Higher cumulative heat units during February's second week may reduce pod setting percentage (Figure 1). Cumulative heat unit has a negative correlation with yield attributes of Sunn hemp (Subrahmaniayan *et al*., 2021).

Application of 20:40:20 kg NPK ha^{-1} recorded a higher pod setting percentage (37.24 %). However, it was on par with 25:50:25 kg NPK ha^{-1}. Supply of 30:60:30 kg NPK ha^{-1} registered with a lower (32.94 %) pod setting percentage. Application of nitrogenous fertilizers during the flowering stage may result in more flower dropping. A similar outcome was confirmed by Chakma *et al*. (2020) in soybean.

January last week sown crop coupled with 20:40:20 kg NPK ha^{-1} registered a higher pod setting percentage (43.96 %). It was statistically on par with sowing during January's fourth week with nutrient levels of 25:50:25 (41.01 %) and 30:60:30 kg NPK ha^{-1} (41.63 %). February second week sown crop along with 30:60:30 kg NPK ha^{-1} recorded a lower (26.44 %) pod setting percentage.

3.5. Pod filling percentage

The effect of dates of sowing and nutrient levels on pod filling percentage is listed in Table 2. January last week's sown Sunn hemp registered a higher pod filling percentage (65.31 %), which was on par (61.15 %) with February's first week sown crop. A lower pod filling percentage (58.12 %) was attributed to February's second week sown crop. Pod filling percentage is negatively correlated with CHU (Figure 1). The increased temperature during February's second week sown crop may result in higher GDD and poor filling percentage (Subrahmaniyan *et al*., 2021)

3.6. Seed yield

The effect of dates of sowing and nutrient levels on seed yield is listed in Table 3. Sunn hemp sown during the last week of January registered with higher seed yield (1380 kg ha^{-1}) than February's first week sown crop (936 kg ha^{-1}). January fourth week sown crop recorded a 32.2% yield increase over February first week sown crop. The seed yield of Sunn hemp was positively correlated with relative thermal disparity (Figure 2). Yield reduction in late-sown crops may attributed to high temperatures prevailing during crop growth and resulting in reduced accumulation of photosynthates (Taruna *et al.*, 2013). Increased yield attributes in earlier sowing dates may produce higher seed yield (Banerjee *et al*., 2021).

Application of nutrients @ 30:60:30 kg NPK ha^{-1} produced higher seed yield (1352 kg ha^{-1}). Lower seed yield (910 kg ha^{-1}) was attributed to the nutrient level of 12.5 t FYM ha^{-1}. Higher accessibility of nutrients with higher doses of fertilizer led to better absorption and translocation of nutrients which may produce increased seed yield (Sanggonda and Eshanna, 2018; Sarika *et al*., 2022)

Table 1. Effect of dates of sowing and nutrient levels on yield parameters of Sunn hemp

Treatments	Number of pods plant^{-1}					Number of seeds pod^{-1}					Seed Index				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
D_1	18.7	21.0	20.2	14.9	18.7	9.82	10.12	10.83	9.83	10.15	2.36	2.24	2.43	2.35	2.34
D_2	13.5	14.9	16.8	12.8	14.5	9.22	9.37	9.60	8.87	9.26	2.08	2.23	2.30	2.06	2.17
D_3	13.3	15.6	18.5	16.7	16.0	8.62	9.22	9.30	8.62	8.94	2.01	2.15	2.19	1.99	2.09
Mean	15.2	17.2	18.5	14.8		9.22	9.57	9.91	9.10		2.15	2.21	2.31	2.13	
	D	N	D x N	N x D		D	N	D x N	N x D		D	N	D x N	N x D	
SED	0.55	0.77	1.08	1.08		0.34	0.37	0.65	0.64		0.07	0.08	0.15	0.15	
CD (0.05)	1.29	1.64	2.11	2.11		0.94	NS	NS	NS		NS	NS	NS	NS	

(D_1 - sowing during January 4th week; D_2 - sowing during February 1st week; D_3 - sowing during February 2nd week; N_1 - 20:40:20 kg NPK ha^{-1}; N_2 - 25:50:25 kg NPK ha^{-1}; N_3 - 30:60:30 kg NPK ha^{-1} and N_4 - 12.5 tons of FYM ha^{-1})

Table 2. Effect of dates of sowing and nutrient levels on pod setting and filling percentage of Sunn hemp

Treatments	Pod setting percentage					Pod filling percentage				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
D_1	43.97	41.01	41.63	35.85	40.61	62.32	67.61	69.86	61.45	65.31
D_2	38.67	35.39	30.75	29.94	33.69	60.64	60.56	63.61	59.81	61.15
D_3	29.09	27.78	26.44	35.69	29.75	57.77	57.99	61.55	55.16	58.12
Mean	37.24	34.73	32.94	33.83		60.24	62.05	65.01	58.80	
	D	N	D x N	N x D		D	N	D x N	N x D	
SED	1.38	1.22	2.28	2.11		1.87	2.27	3.88	3.93	
CD (0.05)	3.82	2.55	5.36	4.42		5.20	NS	NS	NS	

(D_1 - sowing during January 4th week; D_2 - sowing during February 1st week; D_3 - sowing during February 2nd week; N_1 - 20:40:20 kg NPK ha^{-1}; N_2 - 25:50:25 kg NPK ha^{-1}; N_3 - 30:60:30 kg NPK ha^{-1} and N_4 - 12.5 tons of FYM ha^{-1})

Figure 1. Effect of cumulative heat units (CHU) on yield attributes of Sunn hemp

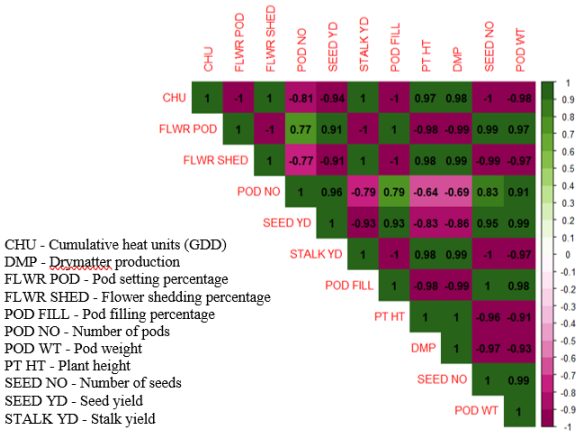

Figure 2. Effect of relative thermal disparity (RTD) on yield attributes of Sunn hemp

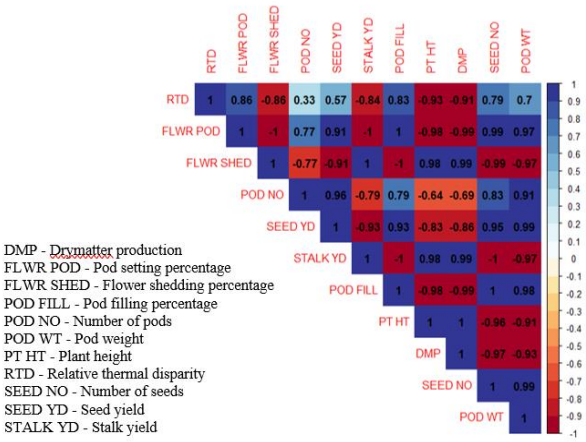

Table 3. Effect of dates of sowing and nutrient levels on yield of Sunn hemp

Treatments	Seed yield					Stalk yield				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
D_1	1322	1470	1657	1071	1380	20.40	21.25	21.65	15.40	19.68
D_2	825	985	1190	742	936	27.87	28.00	29.41	24.13	27.35
D_3	732	985	1209	917	961	26.94	32.02	35.12	30.86	31.24
Mean	960	1147	1352	910		25.07	27.09	28.73	23.46	
	D	N	D x N	N x D		D	N	D x N	N x D	
SED	35.6	28.7	55.9	49.7		1.18	0.88	1.77	1.53	
CD (0.05)	98.9	60.3	132.7	104.4		3.28	1.85	4.26	3.21	

(D_1 - sowing during January 4th week; D_2 - sowing during February 1st week; D_3 - sowing during February 2nd week; N_1 - 20:40:20 kg NPK ha^{-1}; N_2 - 25:50:25 kg NPK ha^{-1}; N_3 - 30:60:30 kg NPK ha^{-1} and N_4 - 12.5 tons of FYM ha^{-1})

Sunn hemp sown during the last week of January coupled with nutrient level of 30:60:30 kg NPK ha^{-1} produced a higher seed yield (1657 kg ha^{-1}) than February second week sown crop with a nutrient level of 20:40:20 kg NPK ha^{-1} (732 kg ha^{-1}). Higher yield attributes recorded with January last week's sown crop and 30:60:30 kg NPK ha^{-1} applied plot may result in higher seed yield.

3.7. Stalk yield

The effect of dates of sowing and nutrient levels on stalk yield is listed in Table 3. Sunn hemp sown during February's second week was recorded with increased stalk yield (31.24 q ha^{-1}). Last week of January sown Sunn hemp recorded lower stalk yield (19.68 q ha^{-1}). Increased GDD accumulation over late sowing may result in higher stalk yield, which has a highly positive correlation (Figure 1). Increased GDD accumulation positively correlated with DMP (Subrahmaniyan *et al*., 2021).

Supply of nutrients at the nutrient level of 30:60:30 kg ha^{-1} registered higher stalk yield (28.73 q ha^{-1}) which was statistically similar to the nutrient level of 25:50:25 kg NPK ha^{-1} (27.09 q ha^{-1}). Application of FYM @ 12.5 t ha^{-1} obtained a lower stalk yield(23.46 q ha^{-1}). Application of higher levels of nutrients may result in increased stalk yield due to effective translocation of nutrients (Sarika *et al*., 2022).

Sunn hemp sown during February's second week with 30:60:30 kg NPK ha^{-1} produced a higher stalk yield (35.12 q ha^{-1}) than Sunn hemp

sown during the last week of January with 12.5 t FYM ha^{-1} applied plot (15.04 q ha^{-1}).

4. CONCLUSION

From the above results, it is concluded that the sowing of Sunn hemp during the last week of February with the nutrient level of 30:60:30 kg NPK ha^{-1} has produced better yield and yield attributes in the Coimbatore region of Tamil Nadu.

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

This research article was written by our own with original research works carried out by us.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There were no conflicts of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required. If anything is required from the MS, certainly, this will be extended by communicating with the corresponding author through the corresponding official mail; ponarasan1999@gmail.com-

Author contributions

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Experiments - A. Pon Arasan

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Writing original draft - A. Pon Arasan

Writing-reviewing & editing - S. Sanbagavalli, N. Sakthivel, R. Vigneshwari, A. Pon Arasan

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