Standardization of nipping technique for enhancement of seed yield and quality in sunn hemp

ABSTRACT

A field experiment entitled "standardization of nipping technique for enhancement of seed yield and quality in sunn hemp" was conducted during *Kharif*, 2019-20 and 2020-21 at Seed Production Block, NSP, Seed Unit, UAS, Raichur. The experiment was laid out in a randomized complete block design with fifteen treatments including nipping and foliar spray of cycocel and their combinations in three replications. The results emanated from the experiment recorded significantly maximum plant height (cm), early 50 per cent flowering and maturity with no nipping (T_1) treatment. Whereas in seed yield and quality parameters, nipping at 30 and 40 DAS and foliar spray of cycocel at 50 DAS (T_{15}) recorded significantly maximum number of branches, number of pods per plant, seed yield per plant, seed yield (q ha^{-1}), seed germination (%), total seedling length (cm), seedling dry weight (mg) and seedling vigour index. While the nipping at 30 DAS and foliar spray of cycocel @ 1000 ppm at 40 DAS (T_{12}) is a better option in terms of obtaining higher net returns and B:C ratio in sunn hemp. Whereas, maximum cost of cultivation was found in nipping at 30, 40 DAS and 50 DAS (T_8) in both years.

Keywords: Nipping, cycocel and green manuring

Introduction

Green manuring is an age old practice of farming for maintaining soil fertility. However, the advent of green revolution has not only increased chemical fertilizer consumption, but also marginalized the use of green manures in intensive cropping systems. This is evident from the declining area under green manure crops over a period of time. The area under green manure crops is estimated at as 1.23 million ha (Anon.Anonymous, 2015) in India.

India has changed from a region of food scarcity to food security by increased fertilizer use with subsidized prices but the use of organic manures including green manure crops, declined substantially. Inorganic fertilizers are becoming more expensive recently besides sustainability of soil productivity is in vogue. Green manure crops are low cost and effective technology in minimizing the cost of fertilizers and safeguarding soil health and productivity. Almost all green manure crops which are used for in-situ or ex-situ incorporation contains all the plant nutrients which are essential for enhancing crop growth and to sustain soil health.

At present, farmers are practicing green manuring only in 6.7 million hectares during *Kharif* which account for 4.5 per cent of net sown area (1.23 million hectares) in the country (Anon.Anonymous, 2015). The practice of green manuring is most common in rice growing states like A.P., U.P., Karnataka, Punjab and Orissa which contribute 41, 16, 11, 6 and 5 per cent to the total area under green manuring in India, respectively. Whereas, the share of Gujarat (3 %), M. P (3 %), Himachal Pradesh (2 %) and Haryana (1.7 %) is not very encouraging and constant efforts has to be made at all levels to bring more area under green manuring that too under irrigated conditions to sustain the productivity of crop and protection of soil health.

Green manuring is a practice of incorporating green plant biomass into the cultivated fields, which is one of the most effective and environmentally sound method of manuring crops. In-situ incorporation of green manure crops provide an opportunity to improve soil physico-chemical condition, cut down the use of chemical fertilizers, which are often blamed for causing environmental pollution and escalating the cost of cultivation of crops. Interest towards green manure crops has been renewed with the growing emphasis on sustained soil productivity in agricultural systems. The benefits deriving from green manure crops are directly related to the amount of biomass and nutrients added into the soil. Biomass production of green manure crops varies widely according to the species of the legumes, environmental conditions, nature of incorporation, native soil fertility, crop management practices and age of green manure crops at the time of incorporation (Fageria, 2007).

Almost all green manure crops which are used for in-situ or ex-situ incorporation contain all the plant nutrients which are essential for growth and development of any plant species. The main green manure crops grown in India are dhaincha, sunn hemp, wild indigo, pillipesara, cowpea, cluster bean, greengram, mung bean and berseem.

Among the green manure crops sunn hemp (*Crotalaria juncea*) is one of the most important green manure crops which is grown all over India. Sunn hemp, a member of the legume family (*Fabaceae*), has great potential as an annually renewable, multi-purpose fiber crop. It is the most important species of *Crotalaria* genus, which is comprised of over 350 species located in the tropics and subtropics of both the hemispheres. As one of the most widely grown green manure crop throughout the tropics, sunn hemp is often grown in rotation with several different crop species it can also be used as fiber and fodder. It is being cultivated in an area of 11,000 hectares with an annual production of 46,100 metric tons (Anon., 2016). The country's average productivity of sunn hemp crop is 681 kg/ha. Green manuring with sunn hemp improves the soil fertility by addition of large quantities of organic matter besides nitrogen to the soil. *Sunn hemp* can fix about 50-60 kg N/ha within 60-90 days of cultivation. It provides 60 kg N/ha to the soil when it is used as green manure. Sunn hemp has the potential to improve soil properties, to build organic matter and sequester carbon into the soil. It can also be used for soil reclamation.

At present the seed multiplication ratio in green manure crops is very low compared to other crops and there is a need to enhance the seed multiplication rate. Nipping is an important agronomic practice of removal of apical bud which helps to reduce the apical dominance, increase the number of branches, per cent pod set and attains better source sink relationship and enhances the seed yield of plant. The agronomic practices are required to be standardized for realizing yield potential. Among them nipping technique and improvement in reproductive sink per plant are the key factors determining the yield. Reddy and Narayanan (1987) reported that nipping of terminal bud in sesamum activated the dormant lateral buds to produce more branches which finally resulted in higher yield.

Nipping by removing tendrils is an important agronomic practice which helps to reduce apical dominance. These tendrils acts as sink in the plant, thereby affecting the translocation of photosynthesis to the reproductive parts. Nipping of tendrils has been found to increase the number of branches, pod set per cent and better source-sink relation, thereby enhancing the yield in pigeon pea (Arjun Sharma *et al*., 2003). Foliar spray of plant growth regulators are known to increase source-sink relationship due to increased translocation of assimilates towards seeds leading to more number of pods per plant, test weight and germination performance in cowpea (Tonapi and Kulkarni, 1986). Along with nipping practice, application of plant growth regulators also help in efficient utilization of metabolites in certain physiological processes going in plant systems (Antony *et al.*, 2003). Among the various plant growth regulators, cycocel has been reported to be very effective in improving yield and quality of certain field and vegetable crops, which causes retardation of vegetative growth and diversion of assimilates towards reproductive growth (Nerson *et al*., 1989).

Application of cycocel had an inhibitory effect on plant height, increased number of branches and nodules per plant in green gram (Garai and Dutta, 2003).

With the brief background, the present investigation was undertaken to standardize the nipping technique for enhancement of seed yield and quality of sunn hemp

Materials and Methods

The present investigation, comprising fifteen treatments was carried during 2019-20 and 2020-21 at National Seed Project, Seed Production Block, Seed Unit, UAS, Raichur. The treatments which included nipping and foliar spray of cycocel and their combinations at different stages of crop growth are enlisted in Table 1. The experiment was conducted using Randomized Complete Block Design (RCBD) with three replications in open field conditions following 45 cm x 10 cm spacing with the gross and net plot size of 4.5 m x 3.0 m and 3.6 m x 2.8 m, respectively.

The following doses of fertilizers *i.e.* 62.2 kg Nitrogen, 75 kg phosphorus and 65 kg of potash per hectare were applied at the time of sowing as basal dose. Irrigation was provided as and when necessary. Seeds were sown to a depth of 4 to 5 cm by dibbling method as per recommended plant placing. Standard agronomic practices and plant protection measures were adopted as per schedule. Five plants from each plot were randomly chosen and tagged in order to record observations.

The observations on various plant growth, seed yield and quality parameters like plant height, number of branches per plant at 30, 60 DAS and at harvest, 50 per cent flowering, days to maturity, number of pods per plant, seed yield, economics, seed germination, total seedling length, seedling dry weight and seedling vigour index were recorded and the replicated mean data was subjected to statistical analysis and the interpretation of the experimental data was done by using Fischer method of Analysis of Variance technique as outlined by Gomez and Gomez (1984). The level of significance used in F test was 5 per cent for field experiment and 1 per cent for laboratory experiment.

Results and discussion

Influence of nipping and foliar spray of cycocel on plant growth, seed yield and quality of sunn hemp

Plant height (cm)

The data in respect of plant height was recorded at 60 DAS and at harvest was found to be significantly different among the treatments in 2019-20, 2020-21 and pooled data of two years and are presented in Table 2.

From the pooled data of two consecutive years, highest plant height was recorded at 60 DAS (132.3 cm) and at harvest (160.3 cm) in T_1 (no nipping). Whereas, the lowest plant height was observed in T_8 (nipping at 30, 40 and 50 DAS) at 60 DAS (93.3) and at harvest (121.2). Similar trend was observed in 2019-20 and 2020-21, individually.

Nipping and foliar spray of cycocel had negatively influenced the plant height at 60 DAS and at harvest. Highest plant height was observed in the treatment without nipping (T_1) and it was remarkably higher than treatment including pinching and cycocel spray i.e. T_8 (nipping at 30, 40 and 50 DAS) at 60 DAS and at harvest in 2019-20, 2020-21 and pooled mean data of two years, respectively. Reduced plant height due to pinching could be attributed to relative behaviour of sink and source and removal of apical dominance which lead to termination of vertical growth of the nipped plants (Abdali *et al.*, 2014). These findings are consistent with Mishra and Nayak (1997). Cycocel acts in the sub-apical system, inhibiting cell division and preventing cell elongation due to its anti-gibberellic nature, the plant becomes small as the internodes fail to extend (Rajyalakshmi and Rajasekhar, 2014). By preventing the conversion of gurancyl pyrophosphate to copalyl pyrophosphate, cycocel, an anti-gibberellin dwarfing chemical, causes gibberellin deficit in plants and reduce its growth (Moore, 1980). These findings are in line with Asghar *et al.* (1997) in okra, Asane *et al.* (1998) in pea and Mahorkar (2007) in okra.

Number of branches per plant

The data in respect of number of branches per plant was recorded at 60 DAS and at harvest was found to be significantly different among the treatments in 2019-20, 2020-21 and pooled data of two years and are presented in Table 2.

The pooled data of two years at 60 DAS and at harvest indicated that, T_{15} (nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS) recorded significantly maximum number of branches per plant(14.3) at 60 DAS and at harvest (14.4) and lowest in T_1 (no nipping) (6.8) at 60 DAS and at harvest (6.8). Similar trend was recorded in 2019-20 and 2020-21.

The number of branches noticed at 60 DAS and at harvest differed significantly among the treatments. The maximum number of branches per plant were recorded in T_{15} (nipping at 30, 40 DAS and foliar spray with cycocel @ 1000 ppm at 50 DAS) at 60 DAS and at harvest. It might be due to better cell division and cell elongation and diverting all the food material leading to higher biomass production resulting in better plant growth and development (Kumar and Srivastava, 2013). The removal of apical dominance might have promoted the development of lateral buds, resulting in more branches per plant (Pathania *et al.*, 2000). The terminal bud clipping exercise may have efficaciously altered crop architecture by activating lateral dormant buds by arresting terminal growth, which in turn might have increased the lateral branches, thereby allowing for better development of source and sink features in sesame and therefore facilitating a significant increase in yield (Singh *et al*., 2013a, Kokilavani *et al*., (2007) and Imayavaranban, (2000). Similar findings have been reported by Sajjan and Jamadhar (2003) and Mahorkar (2007) in okra.

Days to 50 per cent flowering and maturity

The data in respect of days to 50 per cent flowering and maturity was found to be significantly different among the treatments in 2019-20, 2020-21 and pooled data of both years and are presented in Table 3.

The pooled mean data of two years indicated that, T_{15} (nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS) recorded maximum number of days taken to 50 per cent flowering(60.74 days) and maturity (135.76 days) and the least number of days to 50 per cent flowering (52.51 days) and maturity (125.31 days) in T_1 (no nipping).Similar trend was noticed in 2019-20 and 2020-21.

Nipping and spraying of growth retardant cycocel @ 1000 ppm delayed the days to 50 per cent flowering and maturity. This might be because the plants continued their vegetative growth after apical section was clipped, and the new shoots that emerged on the pinched plants took longer to initiate flower buds and mature physiologically. With respect to days to 50 per cent flowering and maturity, nipped plants took more time to grow compared to non-nipped plants. Perhaps, pinching helped in altering the source-sink relationship thereby advancing the reproductive phase. These results are in close conformity with earlier reports of Grawal *et al*. (2004) in chrysanthemum, Srivastava *et al.* (2005) in marigold cv. Pusa Basanti Gainda, Sharma *et al*. (2012) in African marigold and Ravneet *et al*. (2012) in marigold cv. Pusa Narangi Gainda

Number of pods per plant, seed yield per plant (g) and seed yield (q ha^{-1})

Data pertaining to number of per pods, seed yield per plant (g) and seed yield (q ha^{-1})of sunn hemp impacted by cycocel foliar application and nipping was found to be significantly different among the treatments in 2019-20, 2020-21 and pooled data of both years and are presented in Table 4.

The pooled mean data of two years indicated that, T_{15} (nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS) documented highest number of pods per plant (71.50), seed yield per plant (21.65 g) and seed yield (5.66 q ha^{-1}) and the less number of pods per plant in T_1 (no nipping) (52.59), seed yield per plant (13.96 g) and seed yield (4.01 q ha^{-1}). Similar trend was observed in 2019-20 and 2020-21, individually.

A number of factors exhibit direct or indirect effects on seed production. The higher seed yield is the manifestation of more number of branches, pod number per plant due to nipping and foliar spray of cycocel. On the basis of the above findings, it can be concluded that nipping and foliar spray of cycocel produced higher pods per plant and seed yield per plant compared to control and other treatments. It could be due to nipping with manual and chemical sprays of growth retardants like cycocel, might break the apical dominance and efficiently modifies crop architecture by activating latent lateral branches, resulting in more lateral branches and ultimately more pods per plant, which may resulted in greater chance for development of source and sink relationship and thereby would have facilitated a significant increase in the yield attributes and yield in pigeonpea and this has also been reported by Singh *et al.* (2013a) in sesame, Mallesha *et al.*, (2014) in pigeonpea, Lizabeni and Rajesh (2017) in sesamum, Baloch and Zubair (2010) in chickpea.

Economics of sunn hemp seed production as influenced by nipping and foliar spray of cycocel

Data pertaining to cost of cultivation (Rs ha^{-1}), gross returns (Rs ha^{-1}), net returns (Rs ha^{-1}) and B:C ratio of sunn hemp as influenced by nipping and foliar application of cycocel was found to be significantly different among the treatments in 2019-20, 2020-21 and pooled data of both years and are presented in Table 5.

Cost of cultivation

With respect to nipping and foliar application of cycocel, T_8 (nipping at 30, 40 DAS and 50 DAS) registered the higher cost of cultivation (Rs. 47476 ha^{-1}). Whereas, T_1 (no nipping) had recorded the least cost of cultivation (Rs. 39307 ha^{-1}) on pooled basis. The trend was similar in 2019-20 and 2020-21.

Gross returns

Cycocel foliar spray and nipping had an impact on gross returns in 2019-20, 2020-21 and as well as in pooled data. The pooled data showed that maximum returns was significantly higher in T_{15} (nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS) (Rs. 56400 ha^{-1})which was on par with T_5 (nipping at 30 and 40 DAS) (Rs. 56550ha^{-1}). Whereas, the lowest gross returns was recorded in T_1 (no nipping) (Rs. 40100 ha^{-1}). The trend was similar during 2019-20 and 2020-21.

Net returns

Due to nipping and foliar spray of cycocel during both the years, as well as in pooled data, the net returns differed significantly. The pooled data showed that the net returns was significantly higher in T_{12} (nipping at 30 DAS and foliar spray of cycocel @ 1000 ppm at 40 DAS) (Rs. 11987 ha^{-1}). Whereas the least net returns was observed in T_1 (no nipping) (Rs. 793 ha^{-1}). The trend was similar during 2019-20 and 2020-21.

Benefit cost ratio

The nipping and foliar spray of cycocel influenced the B:C ratio in 2019-20 and 2020-21 as well as in pooled data. The pooled data showed maximum B:C ratio was recorded in in T_{12} (nipping at 30 DAS and foliar spray of cycocel @ 1000 ppm at 40 DAS) (1.27)which was on par with T_5 (nipping at 30 and 40 DAS) (1.25). Whereas, the least B:C ratio was observed in T_1 (no nipping) (1.02). The trend was similar during 2019-20 and 2020-21.

The above mentioned data indicates that the treatment including pinching three times i.e. 30, 40 and 50 DAS in T_8 recorded the higher cost of cultivation. This was due to more number of labours needed to perform the nipping operation and spraying of cycocel in this treatment when compared to other treatments which led to an increased cost of cultivation of this particular treatment. Gross returns was higher in treatment involving nipping twice at 30 and 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS (T_{15}) when compared to other treatments, this was due to higher yield recorded in respective treatment and obtained seed yield which could be marketed at good price which ultimately lead to obtaining higher gross returns. These findings are in agreement with Devi *et al*. (2011) and Sanjay (2017) in soybean. The net returns was highly influenced in treatment including nipping at 30 DAS and foliar spray of cycocel @ 1000 ppm (T_{12}) this is due to maximum yield obtained and lesser cost of cultivation recorded when compared to other treatments involving higher cost of cultivation although yield was on par with this treatment. The benefit cost ratio differed significantly among all treatment. Among all, the treatment involving nipping once at 30 DAS and foliar spray of cycocel at 40 DAS recorded highest benefit cost ratio compared to other treatments which involved nipping twice and thrice at different days of sowing and also involving foliar spray of cycocel. It was because the best treatment (T_{12}) recorded benefitable ratio of gross returns by cost of cultivation compared to all treatments. The economically valuable effect of pinching operation was earlier reported by Rathore (2007).

Seed germination

The results on seed germination (%) of sunn hemp as influenced by nipping and foliar spray of cycocel during 2019-20 and 2020-21 and pooled data are presented in Table 6, indicated that germination (%) differed significantly among the treatments.

In the pooled analysis, significant differences were found for seed germination among the treatments. Wherein, maximum seed germination (85.7 %) was registered in T_{15} (nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS) which was followed by T_5 (nipping at 30 and 40 DAS) i.e. 85.9 % and T_{12} (nipping at 30 DAS and foliar spray of cycocel @ 1000 ppm at 40 DAS) (85.2 %) over T_1 (no nipping) (72.8 %).The trend was similar during 2019-20 and 2020-21.

From the above results it is revealed that the plants subjected to nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS (T_{15}) recorded superior seed germination (%) compared to control and other treatments during both years. It might be due to increase in the photosynthetic area leading to higher photosynthetic rate, better assimilation and accumulation of more photosynthates resulting into better seed development which resulted in production of healthy and bold seeds with more reserve food material as synthesized photosynthates might have translocated to seeds. These findings are in resemblance with Sudeep Kumar *et al*. (2010) in fieldbean. Similar increase in germination of seed with apical bud nipping and foliar spray of cycocel was earlier revealed by Venkata Reddy *et al*. (1997) and Sajjanand Jamadar. (2003) in okra, Mc.Creaw and Greig (1986) in capsicum, Sudarshan (2004) in fenugreek and Iyyannagouda (2003) in coriander.

Total seedling length and seedling dry weight

The results on total seedling length (cm) and seedling dry weight (mg) of sunn hemp as influenced by nipping and foliar spray of cycocel during 2019-20 and 2020-21 and pooled data are presented in Table 6, whichdiffered significantly among the treatments.

In pooled mean data of two years, T_{15}(nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS) had a most significant effect on total seedling length and seedling dry weight (21.1 cm and 18.8 mg, respectively). While, the T_1 (no nipping) recorded the least total seedling length and seedling dry weight (13.2 cm and 13.4 mg, respectively).The trend was similar during 2019-20 and 2020-21.

The better development of seed owing to greater accumulation of storage reserves, which in turn might have utilized for germination and seedling growth resulted in maximum total seedling length and seedling dry weight. These results are in resemblance with Sudeep Kumar *et al.* (2010) in fieldbean. Similar increase in total seedling length with apical bud nipping and foliar spray of cycocel was earlier revealed by Gopal Singh and Rama Rao (1993) in sunflower. Narayanaswamy and Channarayappa (1996) in groundnut.

Seedling vigour index

Seedling vigour index I and II

The results on seedling vigour index I and IIof sunn hemp as influenced by nipping and foliar spray of cycocel during 2019-20 and 2020-21 and pooled data are presented in Table 7, whichdiffered significantly among the treatments.

Seedling vigour index-I

Significantly higher (1806) seedling vigour index-I was recorded in plants which received with nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS (T_{15}). Whereas, the lowest seedling vigour index-I (962) was recorded in no nipping (T_1) in pooled mean data of two years. Similar trend was reported in 2019-20, 2020-21. Similar trends was followed in 2019-20 and 2020-21.

Seedling vigour index-II

In pooled mean data of two years, significantly higher seedling vigour index-II was recorded in T_{15} (nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS) (1607). While, the T_1 (no nipping) recorded the lowest seedling vigour index-II (971). Similar trend was followed in 2019-20 and 2020-21.Similar trends was noticed in 2019-20 and 2020-21.

The increase in seedling vigour index I and II was due to higher seed germination per cent, longer length of the root and shoot and seedlings dry weight (Sudeep Kumar *et al.,* 2010). Enhanced translocation of assimilates/photosynthates towards the seeds, as nipping treatment and foliar spray of growth regulators like cycocel are known to boost source and sink relationships, resulting in improved seed germination performance, growth, and dry weight of seedlings (Tonapi and Kulkarni, 1986 in cowpea and Upadhyay, 1994 in chickpea). Similar benefits were also reported in pigeonpea (Deshpande, 1983) and in black gram (Lakshmamma and Rao, 1996) with foliar spray of growth regulators.

Conclusion

The present experimental findings, it can be concluded that T_{15}(nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS) is found to be the best for plant growth, seed yield and quality parameters. Nipping of the sunn hemp crop at 30 and 40 DAS in combination with foliar spray of cycocel @ 1000 ppm at 50 DAS recorded maximum plant growth, yield and seed quality attributing parameters like number of branches per plant, number of pods per plant, seed yield per plantand seed yield (q ha^{-1}) with better seed quality parameters *viz.,* highest seed germination (%), total seedling length (cm), seedling dry weight (mg) and seedling vigour index of the resultant seeds. Hence it is considered as the most ideal and beneficial treatment for nipping to get better yield. With respect to nipping and foliar spray of cycocel the nipping at 30 DAS and foliar spray of cycocel @ 1000 ppm at 40 DAS (T_{12}) is a better option in terms of obtaining higher net returns and B:C ratio. Whereas maximum cost of cultivation was found in nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS (T_{15}) and nipping at 30, 40 DAS and 50 DAS (T_8) respectively.

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Table 1: Treatment details

T_1	Control (No Nipping)
T_2	Nipping at 30 DAS
T_3	Nipping at 40 DAS
T_4	Nipping at 50 DAS
T_5	Nipping at 30 and 40 DAS
T_6	Nipping at 30 and 50 DAS
T_7	Nipping at 40 and 50 DAS
T_8	Nipping at 30, 40 and 50 DAS
T_9	Foliar spraying of cycocel @ 1000 ppm at 30 DAS
T_{10}	Foliar spraying of cycocel @ 1000 ppm at 40 DAS
T_{11}	Foliar spraying of cycocel @ 1000 ppm at 50 DAS
T_{12}	Nipping at 30 DAS and foliar spray of cycocel @ 1000 ppm at 40 DAS
T_{13}	Nipping at 30 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS
T_{14}	Nipping at 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS
T_{15}	Nipping at 30, 40 DAS and foliar spray of cycocel @ 1000 ppm at 50 DAS

Table 2. Plant height and number of branches per plant as influenced by nipping and foliar spray of cycocel in sunn hemp

Treatments	Plant height (cm)									Number of branches per plant					
	30 DAS			60 DAS			At harvest			60 DAS			At harvest		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_{1}	61.1	64.4	**62.7**	132.4	132.3	**132.3**	165.5	162.9	**160.3**	6.6	7.0	**6.8**	6.6	7.0	**6.8**
T_{2}	63.9	64.1	**64.0**	129.5	130.3	**129.9**	159.7	159.0	**158.4**	11.7	12.2	**12.0**	11.7	12.2	**12.0**
T_{3}	61.0	63.3	**62.2**	115.5	117.2	**116.4**	150.2	151.3	**152.4**	11.6	12.2	**11.9**	11.6	12.2	**11.9**
T_{4}	62.6	63.2	**62.9**	108.0	107.8	**107.9**	139.0	139.9	**140.7**	11.0	12.2	**11.6**	11.2	12.4	**11.8**
T_{5}	65.8	64.6	**65.2**	108.5	105.4	**107.0**	139.2	139.4	**139.6**	13.6	12.9	**13.3**	13.6	12.9	**13.2**
T_{6}	63.3	64.1	**63.7**	103.5	99.9	**101.7**	133.6	135.2	**136.7**	13.0	12.4	**12.7**	13.8	12.4	**13.1**
T_{7}	66.4	64.5	**65.5**	101.7	103.3	**102.5**	121.0	121.7	**122.4**	12.2	12.2	**12.2**	12.2	12.3	**12.2**
T_{8}	64.2	65.7	**65.0**	90.7	95.8	**93.3**	120.1	120.7	**121.2**	13.6	14.0	**13.8**	13.8	14.0	**13.9**
T_{9}	64.5	62.4	**63.4**	131.4	128.8	**130.3**	164.1	161.5	**159.0**	10.4	11.2	**10.8**	10.4	11.2	**10.8**
T_{10}	65.2	63.6	**64.4**	117.3	116.2	**116.8**	146.3	146.3	**146.2**	9.0	10.1	**9.6**	9.0	10.1	**9.6**
T_{11}	66.4	62.2	**64.3**	116.0	114.3	**115.1**	154.5	152.4	**150.2**	8.0	9.7	**8.9**	8.3	9.7	**9.0**
T_{12}	63.4	62.9	**63.1**	126.6	124.6	**125.6**	163.6	160.9	**158.2**	13.0	12.9	**12.9**	13.0	12.9	**13.0**
T_{13}	61.9	62.9	**62.4**	119.9	119.2	**119.6**	161.4	158.9	**156.3**	12.4	12.7	**12.5**	12.7	12.7	**12.7**
T_{14}	67.6	64.7	**66.2**	109.4	109.6	**109.5**	147.8	145.5	**143.3**	11.6	12.1	**11.9**	11.9	12.1	**12.0**
T_{15}	62.5	63.8	**63.2**	94.1	96.8	**95.4**	120.1	121.6	**123.2**	14.2	14.4	**14.3**	14.6	14.3	**14.4**
Mean	**64.0**	**63.8**	**63.9**	**113.6**	**113.4**	**113.5**	**145.7**	**145.1**	**144.6**	**11.5**	**11.9**	**11.7**	**11.6**	**11.9**	**11.8**
S.Em±	2.6	1.5	1.5	4.7	1.2	2.5	5.0	2.0	3.1	0.2	0.1	0.1	0.2	0.1	0.2
CD at 5 %	NS	NS	NS	13.6	3.5	7.3	14.4	5.7	8.9	0.5	0.4	0.3	0.7	0.3	0.4

Table 3. Days to 50 per cent flowering and days to maturity as influenced by nipping and foliar spray of cycocel in sunn hemp

Treatments	Days to 50 per cent flowering			Days to maturity		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	52.60	52.42	**52.51**	124.66	125.96	**125.31**
T_2	52.66	52.49	**52.58**	126.00	127.25	**126.63**
T_3	55.66	55.72	**55.69**	126.88	126.88	**126.88**
T_4	57.66	57.69	**57.68**	126.88	128.01	**127.45**
T_5	58.66	58.66	**58.66**	126.66	127.91	**127.29**
T_6	59.67	59.70	**59.68**	132.66	133.01	**132.84**
T_7	59.66	59.72	**59.69**	133.00	133.57	**133.29**
T_8	60.02	60.01	**60.01**	133.00	135.54	**134.27**
T_9	54.60	54.60	**54.60**	133.99	128.27	**131.13**
T_{10}	56.60	56.72	**56.66**	126.66	127.62	**127.14**
T_{11}	57.00	57.11	**57.05**	127.16	128.20	**127.68**
T_{12}	57.33	57.33	**57.33**	128.78	128.78	**128.78**
T_{13}	57.66	57.81	**57.74**	129.33	130.20	**129.77**
T_{14}	58.00	58.11	**58.06**	130.66	131.22	**130.94**
T_{15}	60.67	60.82	**60.74**	134.66	136.85	**135.76**
Mean	**57.23**	**57.26**	**57.25**	**129.40**	**129.95**	**129.68**
S.Em±	0.67	0.81	0.56	1.67	1.79	1.20
CD at 5 %	1.94	2.36	1.62	4.84	5.18	3.49

Table 4. Number of pods per plantand Seed yield as influenced by nipping and foliar spray of cycocel in sunn hemp

Treatments	Number of pods per plant			Seed yield per plant (g)			Seed yield (q ha^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	51.95	53.23	**52.59**	13.72	14.20	**13.96**	4.03	3.99	**4.01**
T_2	59.20	60.01	**59.61**	16.19	17.10	**16.65**	4.86	4.90	**4.88**
T_3	57.80	58.89	**58.35**	15.95	15.99	**15.97**	4.64	4.72	**4.68**
T_4	56.98	57.91	**57.45**	15.84	16.01	**15.92**	4.50	4.52	**4.51**
T_5	69.47	70.12	**69.79**	20.46	20.85	**20.65**	5.61	5.63	**5.62**
T_6	68.20	67.28	**67.74**	19.93	20.12	**20.03**	5.48	5.51	**5.50**
T_7	62.60	63.71	**63.15**	17.29	18.45	**17.87**	5.16	5.26	**5.21**
T_8	65.00	66.32	**65.66**	18.51	19.11	**18.81**	5.50	5.52	**5.51**
T_9	55.20	56.34	**55.77**	15.69	15.83	**15.76**	4.45	4.35	**4.40**
T_{10}	54.60	56.71	**55.65**	14.98	15.71	**15.35**	4.43	4.31	**4.37**
T_{11}	54.20	55.32	**54.76**	14.43	15.09	**14.76**	4.42	4.27	**4.35**
T_{12}	67.00	69.72	**68.36**	18.19	18.36	**18.28**	5.52	5.56	**5.54**
T_{13}	63.80	64.89	**64.35**	17.04	17.33	**17.18**	5.44	5.54	**5.49**
T_{14}	60.40	62.64	**61.52**	16.50	17.01	**16.76**	5.00	5.33	**5.17**
T_{15}	71.00	72.01	**71.50**	21.50	21.80	**21.65**	5.64	5.67	**5.66**
Mean	**61.16**	**62.34**	**61.75**	**17.08**	**17.53**	**17.31**	**4.98**	**5.01**	**4.99**
S.Em±	0.85	0.97	0.74	0.19	0.13	0.14	0.10	0.07	0.06
CD at 5 %	2.46	2.82	2.13	0.56	0.38	0.39	0.29	0.19	0.18

Table 5. Economics of sunn hemp seed production as influenced by nipping and foliar spray of cycocel

Treatments	Cost of cultivation (Rs. ha^{-1})			Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			BC ratio		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	39442	39172	**39307**	40300	39900	**40100**	858	728	**793**	1.02	1.02	**1.02**
T_2	42165	41895	**42030**	48600	49000	**48800**	6435	7105	**6770**	1.15	1.17	**1.16**
T_3	42165	41895	**42030**	46400	47200	**46800**	4235	5305	**4770**	1.10	1.13	**1.11**
T_4	42165	41895	**42030**	45000	45200	**45100**	2835	3305	**3070**	1.07	1.08	**1.07**
T_5	44888	44618	**44753**	56100	56300	**56200**	11212	11682	**11447**	1.25	1.26	**1.26**
T_6	44888	44618	**44753**	54800	55100	**54950**	9912	10482	**10197**	1.22	1.23	**1.23**
T_7	44888	44618	**44753**	51600	52600	**52100**	6712	7982	**7347**	1.15	1.18	**1.16**
T_8	47611	47341	**47476**	55000	55200	**55100**	7389	7859	**7624**	1.16	1.17	**1.16**
T_9	40825	40555	**40690**	44500	43500	**44000**	3675	2945	**3310**	1.09	1.07	**1.08**
T_{10}	40825	40555	**40690**	44300	43100	**43700**	3475	2545	**3010**	1.09	1.06	**1.07**
T_{11}	40825	40555	**40690**	44200	42700	**43450**	3375	2145	**2760**	1.08	1.05	**1.07**
T_{12}	43548	43278	**43413**	55200	55600	**55400**	11652	12322	**11987**	1.27	1.28	**1.28**
T_{13}	43548	43278	**43413**	54400	55400	**54900**	10852	12122	**11487**	1.25	1.28	**1.26**
T_{14}	43548	43278	**43413**	50000	53300	**51650**	6452	10022	**8237**	1.15	1.23	**1.19**
T_{15}	46271	46001	**46136**	56400	56700	**56550**	10129	10699	**10414**	1.22	1.23	**1.23**
Mean	**43173**	**42903**	**43038**	**49787**	**50053**	**49920**	**6613**	**7150**	**6240**	**1.15**	**1.16**	**1.16**
S.Em±	-	-	-	723	851	687	143	159	147	0.02	0.02	0.02
CD at 5 %	-	-	-	2096	2465	1991	414	461	425	0.06	0.07	0.06

Table 6. Seed germination, total seedling length and seedling dry weight as influenced by nipping and foliar spray of cycocel in sunn hemp

Treatments	Germination (%)			Total seedling length (cm)			Seedling dry weight (mg)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	71.5	73.8	**72.8**	13.2	13.3	**13.2**	13.2	13.5	**13.4**
T_2	81.6	83.5	**82.5**	18.6	19.5	**19.0**	16.7	16.7	**16.7**
T_3	81.6	83.1	**82.4**	17.5	18.4	**17.9**	16.2	16.4	**16.3**
T_4	79.6	81.6	**80.6**	16.6	17.1	**16.8**	16.0	16.2	**16.1**
T_5	84.7	86.1	**85.9**	19.9	20.2	**20.1**	18.6	18.7	**18.6**
T_6	77.1	80.5	**78.8**	15.4	15.8	**15.6**	15.5	15.7	**15.6**
T_7	76.3	83.8	**81.3**	15.1	15.8	**15.4**	14.8	16.1	**15.4**
T_8	81.6	83.3	**82.5**	17.7	18.1	**17.9**	16.5	16.5	**16.5**
T_9	80.9	82.6	**81.7**	17.3	17.8	**17.6**	16.7	17.0	**16.9**
T_{10}	79.4	80.7	**80.2**	16.5	16.8	**16.6**	15.7	16.1	**15.9**
T_{11}	73.6	76.0	**74.8**	14.1	14.7	**14.4**	13.5	13.8	**13.7**
T_{12}	84.6	85.7	**85.2**	19.2	19.8	**19.5**	17.3	17.8	**17.5**
T_{13}	84.1	84.9	**84.5**	19.3	19.9	**19.6**	17.0	17.3	**17.1**
T_{14}	74.1	75.8	**75.0**	15.0	15.5	**15.2**	13.9	14.0	**13.9**
T_{15}	84.9	86.6	**85.7**	20.9	21.3	**21.1**	18.7	18.8	**18.8**
Mean	**79.7**	**81.9**	**80.9**	**17.1**	**17.6**	**17.3**	**16.0**	**16.3**	**16.2**
S.Em±	0.2	1.2	0.6	0.1	0.1	0.1	0.1	0.1	0.1
CD at 1 %	0.6	4.7	2.3	0.4	0.2	0.2	0.2	0.3	0.2

Table 7. Seedling vigour index as influenced by nipping and foliar spray of cycocel in sunn hemp

Treatments	Seedling vigour index - I			Seedling vigour index - II		
	2019	2020	Pooled	2019	2020	Pooled
T_1	943	981	**962**	945	998	**971**
T_2	1518	1625	**1572**	1360	1397	**1379**
T_3	1424	1532	**1478**	1322	1367	**1344**
T_4	1319	1393	**1356**	1272	1323	**1297**
T_5	1705	1742	**1723**	1563	1598	**1580**
T_6	1184	1274	**1229**	1191	1261	**1226**
T_7	1153	1321	**1237**	1129	1346	**1237**
T_8	1444	1512	**1478**	1350	1378	**1364**
T_9	1401	1469	**1435**	1352	1405	**1378**
T_{10}	1309	1353	**1331**	1249	1297	**1273**
T_{11}	1039	1116	**1077**	992	1052	**1022**
T_{12}	1627	1700	**1663**	1461	1527	**1494**
T_{13}	1620	1686	**1653**	1425	1471	**1448**
T_{14}	1107	1177	**1142**	1027	1059	**1043**
T_{15}	1773	1840	**1806**	1585	1630	**1608**
Mean	**1371**	**1448**	**1410**	**1282**	**1340**	**1311**
S.Em±	9	20	10	5	21	10
CD at 1 %	35	76	39	18	79	38