The Pharma Innovation Journal 2022; 11(11): 2573-2579

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 2573-2579

www.thepharmajournal.com
Received: 18-08-2022
Accepted: 19-09-2022

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Effect of nipping and foliar spray of nutrients and plant growth hormones on seed yield and quality of dhaincha (*Sesbania aculeata* (Willd.) Pers.)

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Abstract
An investigation was undertaken during *kharif* 2017 in the Department of Seed Science and Technology, College of Agriculture, Bhubaneswar. The field experiment was taken up in Central Farm, OUAT, Bhubaneswar. The experiment was laid out in Split Plot Design with nipping (M_1) and non-nipping (M_2) as the main plot treatments and foliar sprays with nutrients and growth hormone as the sub-plot treatments. The experiment was conducted with four replications. Nipping of terminal buds was done at 60 DAS. Foliar sprays were done at 65 DAS, which included 2% DAP (T_2), MN mixture (0.5% $ZnSO_4$ + 0.3% boric acid) (T_3), 40 ppm NAA (T_4), and combination of all three treatments ($T_5 = T_2 + T_3 + T_4$). One Control (T_1) was also taken in which no foliar spray was done. Growth and yield attributing parameters, seed yield and quality were recorded. Nipping resulted in plant height which was 11.77% lower than that of plants without nipping. Foliar sprays had no significant effect on the plant height. Plants with nipping and foliar spray of 2% DAP + MN mixture + 40 ppm NAA (M_1T_5) recorded lowest plant height. Plants with nipping recorded 63.41% higher number of branches than the plants without nipping, whereas foliar sprays did not bring about any change in the number of branches per plant. Number of pods per plant increased significantly due to nipping, while foliar treatment positively influenced the pod development. The number of pods per plant was highest for T_5, followed by T_4. Number of seeds per pod was positively influenced by nipping and foliar spray treatments. Plants with nipping had higher number of seeds per pod (23.68) as compared to non-nipping (22.25). The treatment T_5 recorded highest number of seeds per pod, which was 20.6% higher than the Control. Mean seed yield per plant from nipping treatment was 17.65 g, as against 16.49 g from plants without nipping. Foliar application with 2% DAP + MN mixture + 40 ppm NAA (T_5) proved to be the most effective foliar spray treatment. Nipping in combination with foliar spray of 2% DAP + MN mixture + 40 ppm NAA gave highest seed yield per hectare of 16.82 q, which was 35.65% higher than M_2T_1 (i.e., non-nipping and no foliar spray). Seed quality parameters such as seed germination remained unaffected with both nipping and foliar spray treatments but parameters such as 1000-seed weight and protein content were influenced by the treatments. Seeds produced from plants without nipping and with foliar spray of 2% DAP + MN mixture + 40 ppm NAA (M_2T_5) recorded 31.36% protein content, followed by M_1T_5 (31.09%). Hence, nipping of terminal buds at 60 DAS, followed by foliar spray of 2% DAP + MN mixture + 40 ppm NAA at 65 DAS proved to be the most effective treatment combination in the experiment and can be used to enhance seed yield and quality of dhaincha.

Keywords: Dhaincha, nipping, foliar application of nutrients and hormones

Introduction
Dhaincha (*Sesbania aculeata* (Willd.) Pers.) is the most commonly used green manure crop as it is inexpensive, quick growing, succulent, easily decomposable and its cultivation is possible even in areas with low water availability, saline soils, ill-drained soils, which receive heavy rainfall (Parlawar *et al*., 2003) [16]. It can produce up to 22.5 tonnes/ha of biomass, the highest among all green manure crops, and has nutrient content of 3.3% N, 0.7% P and 1.3% K (Chandra, 2005) [2]. It is quick germinating and fast-growing crop and bears higher number of nodules that fix atmospheric nitrogen. It is mostly used as *in situ* incorporation which leads to increased water holding capacity and decreased soil loss by erosion. Growing dhaincha crop in the off-season reduces weed proliferation and weed growth and also controls root knot nematodes. The lack of availability of adequate quality seeds at appropriate time at reasonable price for small holding and marginal farmers becomes a major constraint in dhaincha cultivation. Quality seed production of dhaincha is given meagre importance in spite of huge demand from farmers.

Dhaincha seed production is mainly concentrated in states like A.P., U.P., Karnataka, Punjab and Odisha. In addition to its use as a green manure crop, the protein-rich dhaincha seed is required as an animal feed (Hossain *et al*., 2001) [6], which also demands its higher production. Hence, an experiment was undertaken to study the performance of dhaincha with or without nipping and with foliar application of nutrients and plant growth hormone *vis-à-vis* seed yield and quality.

Materials and methods

The investigation was undertaken during *Kharif* 2017 in the Department of Seed Science and Technology, College of Agriculture, Bhubaneswar. The field experiment was taken up in Central Farm, OUAT, Bhubaneswar. The experiment was laid out in Split Plot Design with four replications, nipping (M_1) at 60 DAS and non-nipping (M_2) being the main plot treatments and foliar sprays of nutrients and growth hormone at 65 DAS being the sub-plot treatments. The foliar sprays included, 2% DAP (T_2), MN mixture (0.5% $ZnSO_4$ + 0.3% boric acid) (T_3), 40 ppm NAA (T_4), and combination of all three treatments ($T_5 = T_2 + T_3 + T_4$). An untreated Control (T_1) was also taken in which no foliar spray was done. The field performance was evaluated through study of growth and yield attributing parameters, seed yield and quality.

Results and Discussion

Effect of nipping and foliar spray treatments on plant growth parameters

Plant growth parameters such as plant height and number of branches per plant were significantly affected by both nipping and foliar spray treatments. Nipping of terminal buds led to significantly lower plant height as compared to plants without nipping. The plants with nipping had height 11.77% lower than that of the Control, which was due to suppression of apical dominance. Kathiresan and Duraisamy (2001) [8], Gopal *et al*. (2016) [5] and Nayak *et al*. (2017) [14] in dhaincha also put forth such results by nipping of terminal buds. They recorded lower plant height due to nipping treatment. This was also in accordance to findings of Mandal *et al*. (2017) [11] in dhaincha and Sharma *et al*. (2003) [22] in pigeon pea. Plant height was not significantly affected by the foliar applications but treatment with 40 ppm NAA (T_4) and 2% DAP (T_2) showed slightly higher plant height. Similar findings were stated by Elamathi and Pradeep (2007) [4] in green gram where plant height was more with spray of 2% DAP and 40 ppm NAA. The lowest plant height was recorded with plants without any foliar spray. Though there was no significant effect on plant height due to interaction effect but the lowest plant height was recorded in plants with nipping and foliar spray with 2% DAP + MN mixture + 40 ppm NAA (M_1T_5).

Suppression of apical bud due to nipping leads to increase in the number of primary and secondary branches. Similar results were observed with nipping of dhaincha plants in the present investigation. The plants with nipping recorded 63.41% higher number of branches per plant than those without nipping. The result is in accordance with that of Kathiresan and Duraisamy (2001) [8], Mandal *et al*. (2017) [11] and Nayak *et al*. (2017) [14] in dhaincha. Narayan and Narayan (1987) in sesamum stated that removal of terminal bud leads to activation of dormant lateral buds and hence, higher number of branches is produced. Similar findings were put forth by Patel and Patel (1990) [17] in gram, Reddy (2005) [18] in cowpea, Sajjan *et al*. (2002) [21] in okra and Sharma *et al*. (2003) [22] in pigeon pea. Pandian *et al*. (2001) [15] reported higher number of branches with spray of 2% DAP + 1% K in dhaincha. Interaction effect of nipping and foliar spray did not have any significant effect on the number of branches per plant.

Table 1: Plant height and number of branches per plant of dhaincha at maturity as influenced by nipping of terminal buds and foliar spray treatments

Treatments	Plant height at maturity (cm)			Number of branches per plant		
	M_1	M_2	Mean	M_1	M_2	Mean
T_1: Control	208.00	231.53	219.76	7.50	4.95	6.23
T_2: 2% DAP	209.48	236.80	223.14	7.25	4.83	6.04
T_3: MN mixture	208.18	236.93	222.55	7.85	4.40	6.13
T_4 : 40 ppm NAA	208.43	238.88	223.65	8.43	4.30	6.36
T_5: $T_2 + T_3 + T_4$	207.60	236.55	222.08	7.45	5.05	6.25
Mean	208.34	236.14	222.24	7.70	4.71	6.20
	S.E.M (±)	$CD_{0.05}$	CV	S.E.M (±)	$CD_{0.05}$	CV
M	1.701	7.658	13.42	0.116	0.521	11.42
T	2.052	NS	12.61	0.145	NS	9.67
M x T	2.903	NS		0.205	NS	

The yield and yield attributing characteristics such as number of pods per plant, number of seeds per pod, seed yield per plant and seed yield per hectare were significantly affected by both nipping and foliar spray treatments.

Number of pods per plant was higher with nipping in comparison to without nipping. Nipping of terminal buds resulted in the arrest of apical dominance and hence, the number of branches per plant was increased. This resulted in the increase in number of pods per plant. Similar result was reported by Nayak *et al*. (2017) [14], Dhedhi *et al*. (2017) [3] and Mandal *et al*. (2017) [11] in dhaincha. Plants treated with 2% DAP + MN mixture + 40 ppm NAA recorded highest number of pods per plant followed by MN mixture. Foliar treatment with micronutrients and growth regulators at critical stages leads to effective absorption by plants and translocation to developing pods which produces higher number of pods per plant. Moreover, the results indicate that foliar spray of MN mixture, containing the micronutrients zinc and boron, played an important role in growth and development of the crop. They are the constituents of various enzymatic processes which lead to better production of pods. Boron plays an important role in cell division, cell differentiation, cell development, calcium utilization, translocation of photosynthates and growth regulators from source to sink which helps in maintaining higher leaf area, leaf area index and higher number of pods per plant (Kalyani *et al*., 1993) [7]. Similar results with 2% DAP + MN mixture + 40 ppm NAA was reported by Dhedhi *et al*. (2017) [3] in dhaincha. The

mean number of pods per plant in the first picking was higher than the second picking, which indicates that the first picking contributed more (62.97%) towards the total number of pods per plant as compared to the second picking (37.03%). The interaction effect showed no significant impact on this character but in total highest number of pods per plant was observed with nipping and foliar spray of 2% DAP + MN mixture + 40 ppm NAA (M_1T_5).

Number of seeds per pod was significantly increased by the nipping treatment as compared to non-nipping. In the first picking, there was significant increase in number of seeds per pod with nipping while in second picking nipping did not affect number of seeds per pod significantly. These results were in accordance with the findings by Sajjan *et al*. (2002) [21] in okra, Sudarshan (2004) [24] in fenugreek, Mohanty *et al*. (2015) [12] in African marigold and Reddy *et al*. (2009) [19] in cowpea. Treatment with foliar spray of 2% DAP + MN mixture + 40 ppm NAA showed highest mean number of seeds per pod which was 20.6% higher than Control. Second highest was recorded through spray of MN mixture. This can be due to the fact that micronutrients and growth regulators bring about enhanced growth and development of the plants. Foliar application of micronutrients leads to effective absorption and translocation of growth materials which further increase the number of seeds per pod. Kumar *et al*. (2014) elucidated that in gram number of seeds per pod increased with spray of 50 ppm NAA. Though the interaction effect of nipping and foliar spray was not significant in overall but in the first and second picking plants with nipping and foliar treatment with 2% DAP + MN mixture + 40 ppm NAA recorded higher number of seeds per pod than Control (M_2T_1).

Table 2: Number of pods per plant and seeds per pod of dhaincha as influenced by nipping of terminal buds and foliar spray treatments

Treatments	Number of pods per plant			Number of seeds per pod		
	M_1	M_2	Mean	M_1	M_2	Mean
T_1: Control	55.93	52.13	54.03	22.01	20.52	21.26
T_2: 2% DAP	59.55	54.45	57.00	23.44	21.43	22.44
T_3: MN mixture	62.55	58.75	60.65	24.62	23.12	23.87
T_4: 40 ppm NAA	56.55	53.40	54.98	22.26	21.02	21.64
T_5: $T_2 + T_3 + T_4$	66.28	63.95	65.11	26.09	25.17	25.63
Mean	60.17	56.54	58.35	23.68	22.25	22.97
	S.E.m (±)	$CD_{0.05}$	CV	S.E.m (±)	$CD_{0.05}$	CV
M	0.399	1.795	10.06	0.157	0.707	13.06
T	0.551	1.609	9.67	0.217	0.633	12.67
M x T	0.779	NS		0.307	NS	

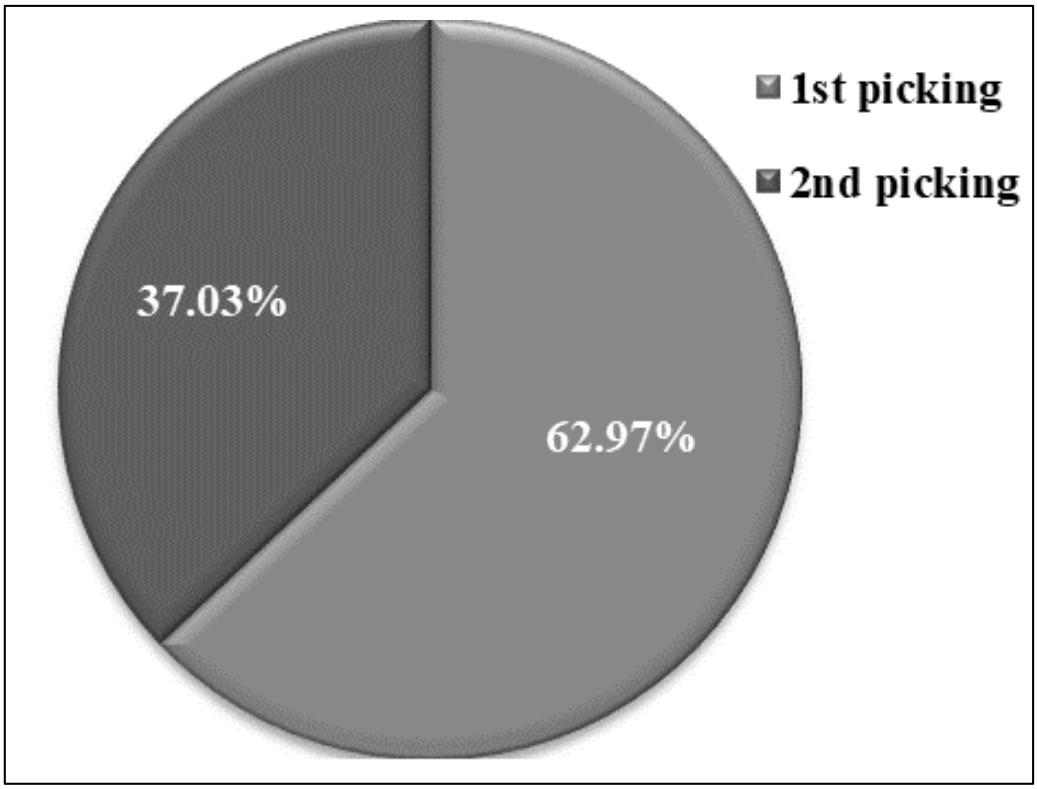

Fig 1: Contribution of first and second pickings to the total number pods per plant of dhaincha as influenced by nipping of terminal buds and foliar spray treatments

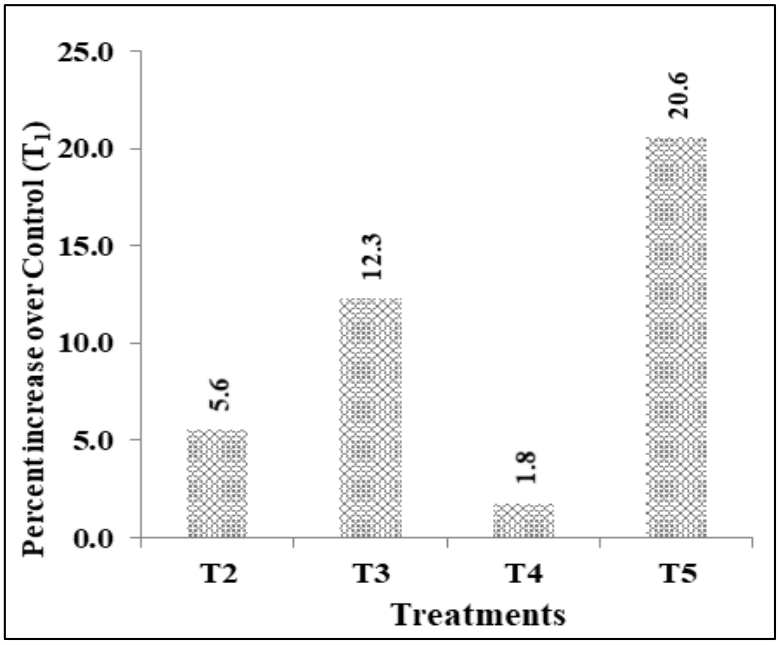

Fig 2: Percent increase in number of seeds per pod due to foliar spray treatments over Control

Seed yield per plant was higher in plants with nipping as compared to without nipping. This can be attributed to the fact that nipping breaks apical dominance and induces development of lateral branches thereby increasing the sites for pod development which leads to more seed yield. The practice of nipping has been seen to increase seed yield of different crops like jute (Bhattacharjee and Mitra, 1999) [1] and Indian mustard (Singh *et al*., 2013). Similar results were stated by Nayak *et al*. (2017) [14] and Dhedhi *et al*. (2017) [3] and Mandal *et al*. (2017) [11] in dhaincha. Foliar application with 2% DAP + MN mixture + 40 ppm NAA recorded highest mean seed yield per plant. It was similar with that of first and second picking. Similar results were reported by Dhedhi *et al*. (2017) [3] in dhaincha. The interaction of nipping and foliar spray had no significant effect on seed yield per plant. However, plants with nipping and foliar spray with 2% DAP + MN mixture + 40 ppm NAA produced 34.36% higher yield per plant over non-nipping and no foliar spray.

Seed yield is the ultimate desirable economic produce. It is influenced by a lot of yield attributing characteristics such as number of pods per plant, number of seeds per pod, seed weight, etc. Genetic factors and management practices also influence the final seed yield. Nipping positively affected seed yield and brought about increase in seed yield per hectare as compared to non-nipping. In the first and second picking also the plants with nipping showed more yield than those without nipping. The higher seed yield due to nipping can be attributed to the fact that a lot of growth characteristics such as pods per plant, higher number of branches per plant, seed yield per plant and seeds per pod were all enhanced by the nipping treatment. This further led to increase in seed yield. This is in conformity with the results of Dhedhi *et al*. (2017) [3], Nayak *et al*. (2017) [14], Mandal *et al*. (2017) [11] and Kathiresan and Duraisamy (2001) [8] in dhaincha.

Table 3: Seed yield per plant and seed yield per hectare of dhaincha as influenced by nipping of terminal buds and foliar spray treatments

Treatments	Seed yield per plant (g)			Seed yield per hectare (q)		
	M_1	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**
T_1: Control	17.20	15.25	16.22	14.00	12.40	13.20
T_2: 2% DAP	17.37	17.03	17.20	14.13	14.01	14.07
T_3: MN mixture	16.57	16.25	16.41	13.63	13.37	13.50
T_4: 40 ppm NAA	16.63	15.65	16.14	13.68	12.84	13.26
T_5: T_2 + T_3 + T_4	20.49	18.25	19.37	16.82	14.85	15.84
Mean	17.65	16.49	17.07	14.45	13.49	13.97
	S.E.M (±)	$CD_{0.05}$	CV	S.E.M (±)	$CD_{0.05}$	CV
M	0.109	0.491	10.86	0.098	0.442	11.15
T	0.279	0.814	10.62	0.231	0.674	9.68
M x T	0.394	NS		0.327	0.954	

Foliar application of 2% DAP + MN mixture + 40 ppm NAA showed the highest seed yield as compared to the Control. All the foliar spray treatment recorded higher seed yield as compared to the Control except 40 ppm NAA whose yield was at par with Control. Increase of yield due to 2% DAP + MN mixture + 40 ppm NAA application can be attributed to the fact that presence of nutrients and micronutrients with growth regulators play an important role in improving necessary growth and development processes in the plant. Boron and zinc are major constituents of enzymatic processes that improve growth and help in better utilization and translocation of photosynthates and growth regulators from source to sink (Kalyani *et al*., 1993) [7]. This was in conformity with the results of Dhedhi *et al*. (2017) [3] and Mandal *et al*. (2017) [11] who stated that highest seed yield in dhaincha by application of 2% DAP + MN mixture + 40 ppm

NAA. However, Nayak *et al*. (2017) [14] stated that in dhaincha highest seed yield was recorded for treatment with MN mixture and the 40 ppm NAA. Highest seed yield was recorded with nipping and foliar of 2% DAP + MN mixture + 40 ppm NAA (M_1T_5) which is in conformity with the findings of Dhedhi *et al*. (2017) [3] and Mandal *et al*. (2017) [11] in dhaincha. Plants without nipping and without foliar spray recorded the lowest seed yield, whereas all the other treatment combinations had seed yield lower than M_1T_5. The treatment M_1T_5 showed 35.65% yield increment, while the treatment M_2T_5 showed 19.76% yield increment over M_2T_1, i.e., non-nipping and no foliar spray. This proves that M_1T_5 is the best treatment combination for improving seed yield per hectare. The first picking contributed more (61.92%) to the total seed yield as compared to the second picking (38.08%).

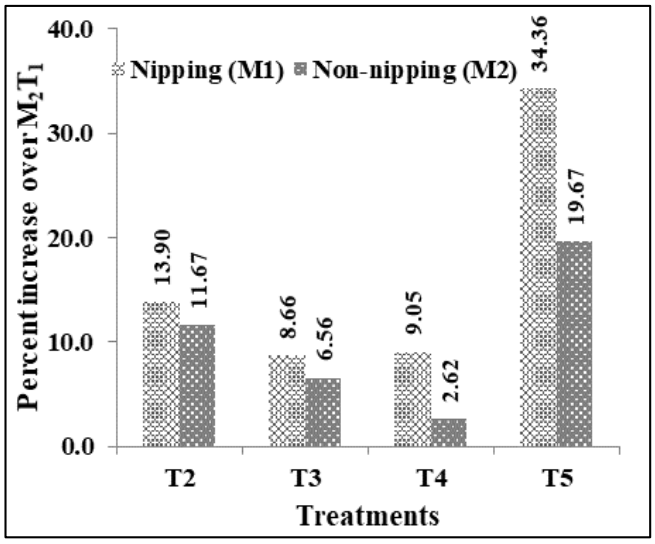

Fig 3: Percent increase in seed yield per plant due to foliar spray treatments with or without nipping over non-nipping and no foliar spray

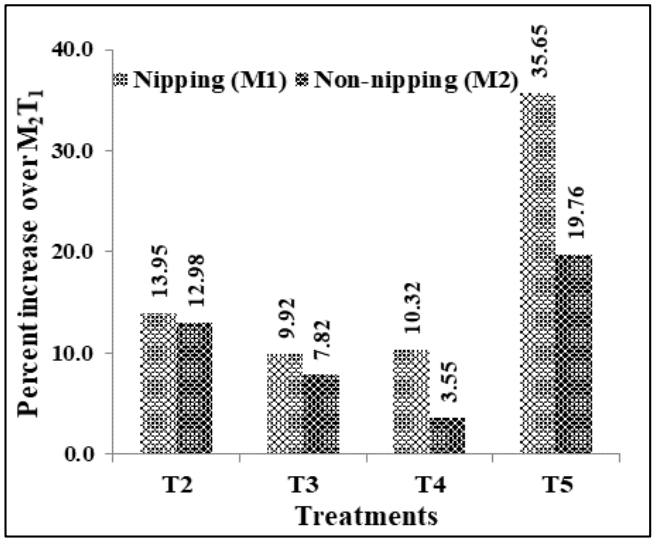

Fig 4: Percent increase in seed yield per ha due to foliar spray treatments with or without nipping over non-nipping and no foliar spray

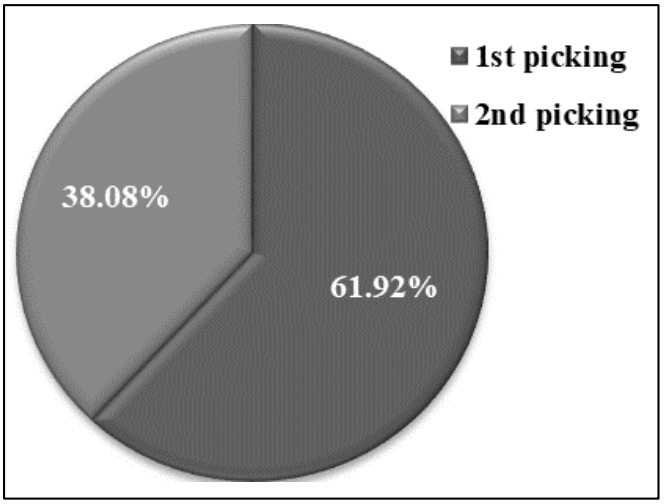

Fig 5: Contribution of first and second pickings to the total seed yield per hectare of dhaincha as influenced by nipping of terminal buds and foliar spray treatments

Nipping and foliar application of micronutrients and growth regulators can affect the seed quality parameters such as 1000-seed weight, seed germination and protein content of seed. 1000-seed weight was not significantly affected by the nipping treatments. Foliar spray treatments with 2% DAP + MN mixture + 40 ppm NAA (T_5) recorded highest 1000-seed weight which was followed by 2% DAP (T_2) application. Similar results were observed in both first and second pickings. This observation was in accordance with the findings of Kavimani *et al*. (1997) [9] in dhaincha and Pandian *et al*. (2001) [15] in greengram. Both of the reports stated that 2% DAP recorded highest 1000-seed weight. Increase of 1000-seed weight with foliar spray can be attributed to the fact that the micronutrients and growth regulators help in efficient production and translocation of photosynthates. 1000-seed weight remained unaffected due to the interaction effect of nipping and foliar sprays.

Protein content of the seed determines its nutritional quality. The protein content (%) remained unaffected by the nipping treatment. Though the protein content of seeds from plants with nipping was slightly higher than that without nipping, the difference was not significant. However, Reddy *et al*. (1997) in okra and Reddy (2005) [18] in cowpea stated that there was increase in protein content of the crops due to nipping. Foliar application had significant effect on the protein content of seeds. The highest protein content was recorded for seeds from plant treated with 2% DAP + MN mixture + 40 ppm NAA which was 8.43% higher than that of Control. The first and second picking followed similar trend. Though the interaction effect had no significant influence on the protein content but the highest protein content was recorded for seeds produced from plants without nipping and foliar spray with 2% DAP + MN mixture + 40 ppm NAA (M_2T_5 – 31.36%), followed by M_1T_5 (31.09%).

Table 4: 1000-seed weight and protein content of dhaincha as influenced by nipping of terminal buds and foliar spray treatments

Treatments	1000-seed weight (g)			Protein content (%)		
	M1	**M2**	**Mean**	**M1**	**M2**	**Mean**
T1: Control	17.18	17.00	17.09	29.01	28.60	28.80
T2: 2% DAP	18.18	17.99	18.08	30.73	30.42	30.57
T3: MN mixture	18.20	18.02	18.11	29.49	29.46	29.48
T4: 40 ppm NAA	17.25	17.08	17.16	29.33	29.30	29.31
T5: T2 + T3 + T4	18.38	18.19	18.28	31.09	31.36	31.23
Mean	17.84	17.66	17.75	29.93	29.83	29.88
	S.E.M (±)	CD0.05	CV	S.E.M (±)	CD0.05	CV
M	0.066	NS	9.66	0.162	NS	10.59
T	0.047	0.136	7.74	0.190	0.555	13.80
M x T	0.066	NS		0.269	NS	

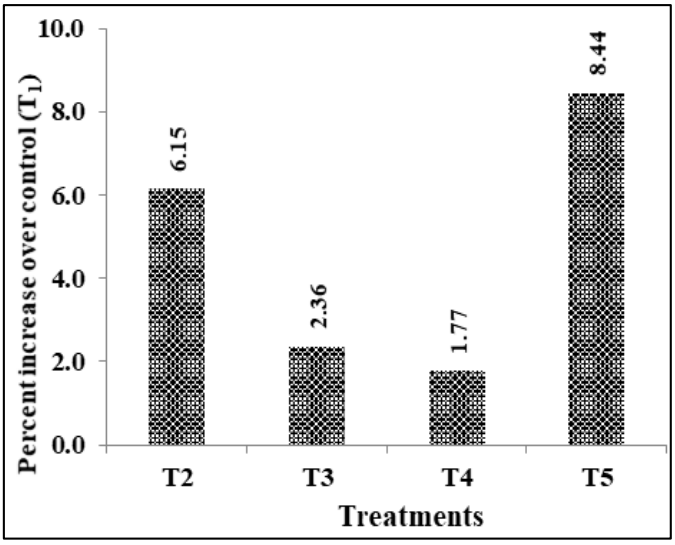

Fig 6: Percent increase in protein content due to foliar spray treatments over Control

Seed germination is an important seed qualitative character which helps in determining the stand quality of a crop. However, it remained unaffected by nipping and foliar treatments. Overall, the seed germination value of plants with nipping was slightly higher than that of Control but it was less than Control for the first and second pickings. This was in contradiction to the findings of Dhedhi *et al*. (2017) [3] in dhaincha and Sajjan *et al*. (2002) [21] in okra. In the present investigation, foliar application also had no positive impact on mean seed germination. In fact, all the treatments recorded lower seed germination than that of Control. This result is not in accordance to the findings of Dhedhi *et al*. (2017) [3] who stated that there was increase in seed germination of seeds by application of 40 ppm NAA. Seed germination remained unaffected by the interaction effect.

Table 5: Germination of dhaincha seeds as influenced by nipping of terminal buds and foliar spray treatments

Treatments	Germination (%)								
	1st picking			2nd picking			Overall		
	M1	**M2**	**Mean**	**M1**	**M2**	**Mean**	**M1**	**M2**	**Mean**
T1: Control	88.50 (9.41)	87.50 (9.35)	88.00 (9.38)	80.50 (8.97)	79.50 (8.91)	80.00 (8.94)	84.50 (9.19)	83.50 (9.14)	84.00 (9.16)
T2: 2% DAP	81.75 (9.04)	87.25 (9.34)	84.50 (9.19)	73.75 (8.58)	78.75 (8.85)	76.25 (8.72)	77.75 (8.82)	83.00 (9.11)	80.38 (8.96)
T3: MN mixture	87.50 (9.35)	86.75 (9.31)	87.13 (9.33)	79.50 (8.91)	78.75 (8.87)	79.13 (8.89)	83.50 (9.14)	82.75 (9.10)	83.13 (9.12)
T4: 40 ppm NAA	85.00 (9.22)	85.25 (9.23)	85.13 (9.22)	77.00 (8.76)	77.25 (8.78)	77.13 (8.77)	81.00 (9.00)	81.25 (9.01)	81.13 (9.01)
T5: T2 + T3 + T4	85.00 (9.22)	87.75 (9.36)	86.38 (9.29)	77.00 (8.77)	79.25 (8.88)	78.13 (8.83)	81.00 (9.00)	83.50 (9.14)	82.25 (9.07)
Mean	85.55 (9.25)	86.90 (9.32)	86.23 (9.28)	77.55 (8.80)	78.70 (8.86)	78.13 (8.83)	81.55 (9.03)	82.80 (9.10)	82.18 (9.06)
	S.E.m (±)	CD0.05	CV	S.E.m (±)	CD0.05	CV	S.E.m (±)	CD0.05	CV
M	0.037	NS	9.78	0.112	NS	8.65	0.035	NS	9.73
T	0.067	NS	7.03	0.172	NS	9.51	0.066	NS	8.06
M x T	0.094	NS		0.243	NS		0.094	NS	

N.B. Figures in the parentheses are square root transformed values

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