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Standardizing Drip Irrigation Scheduling and NPK Levels on Economics and Energy use of Mentha (*Mentha arvensis*) Crop in Tarai Regions of Uttarakhand

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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

To standardize the scheduling of drip irrigation and NPK levels on yield, economics and energy use of mentha crop, this field study was executed at G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), India in the Norman E. Borlaug Crop Research center during the spring season of 2017. This experiment was performed in Factorial RBD having three replications. Three drip irrigation scheduling levels, 75%, 100% and 125% based on cumulative pan evaporation (CPE) loss with one control as a conventional flood and three NPK levels, 75%, 100%

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and 125% are taken as treatments. Experimental data conclude that drip irrigation CPE and NPK levels at 125% recorded the maximum fresh herbage (29699 and 30027 kg/ha), oil yield (260 and 274 kg/ha) and farm economics. Further the highest oil content was recorded with 125% NPK level (0.92%) but in case of CPE level, it is highest with 75% CPE (0.94%). Highest total energy input and output recorded with 125% CPE and 125% NPK levels, being 18674 and 18383 MJ/ha (input), 51988 MJ/ha and 55099 MJ/ha (output), respectively. Energy use efficiency and energy productivity increase with increase in irrigation levels and NPK dose, being highest with 125% CPE and 125% NPK dose. Again Drip irrigation and NPK level of 125% recorded maximum energy intensiveness of 0.24 MJ/Rs and 0.23 MJ/Rs and net energy gain of 33604 MJ/ha and 36425 MJ/ha, respectively.

Keywords: Mentha; drip irrigation and fertilizer; energy.

1. INTRODUCTION

Mentha, an aromatic perennial herb, belongs to the family Lamiaceae. Among the 40 mint species, *Japanese* mint (*Mentha arvensis* L.), peppermint (*Mentha piperita* L.), bergamot mint (*Mentha citrata* E.), and spearmint (*Mentha spicata* L.) are commercially cultivated in India. *Japanese* mint (*Mentha arvensis* L.) accounts for more than 80 per cent of total area. It is one of the most extensively cultivated mint species all over the world due to its high menthol content. It is a rich source of natural menthol as well as other ingredients such as mint terpenes, menthone, isomenthone and menthyl acetate, which are extensively used in pharmaceutical, cosmetic, food, and flavor industries.

Herbage is the harvestable product of mint thus irrigation and fertilization are the key inputs for securing optimum productivity and quality. Mint requires 10-12 irrigations depending on soil texture and weather conditions during the crop growing period. It is a shallow rooted crop and its active growth period coincides with pre- monsoon hot summer months, higher soil and air temperatures are high leading to high ET. Mint being a leafy herb, responds to frequent irrigations during dry season months [1]. The favourable effects of irrigation in enhancing herb and essential oil yield of various mint species have also been reported by [2]. Conventionally, mint is irrigated through surface flood method having low water use efficiency (30-40 per cent). Both excess as well as suboptimal soil moisture conditions decrease the growth, herb and oil yield of mint crop [1]. Stress reduces plant biomass including plant height and leaf area, its lateral spread and dry matter accumulation. Water stress impairs numerous metabolic and physiological processes in plants such as nutrient uptake and their transport [3]. Hence, maintaining adequate soil moisture is essential to minimize the adverse effect of moisture stress, which can be achieved through proper monitoring and scheduling of irrigation. Water has been and would be the most precious input for sustainable yields and higher efficiency of other inputs.

Mint is a heavy feeder of nutrients and removes substantial quantities of N, P and K [4]. Adequate supply of nutrients increased herbage and oil yields due to production of taller plants, more branches and leaves, superior leaf- stem ratio and increased dry matter [5]. Among various nutrients, nitrogen is the most effective and important nutrient, which regulates vegetative growth, herbage and oil yields. It is the essential component of cell molecules including chlorophyll, nucleic acids, amino acids, ATP and a number of plant hormones. Behera *et al*. [6] observed significant increase in herbage and oil yields due to N application in Japanese mint.

Phosphorus is a nutrient largely used in energy transfer processes in cells, mainly as a component of ATP. Adequate P fertilization in mint helps in ramification of the root system which increased the number of suckers in plants (Rehman *et al*., 2003) and finally enhanced the herbage and oil yields. Behera *et al*. [7] observed the maximum herbage (35,798 kg ha-1) and oil yields (260 kg ha-1) of mint with 100% NPK application. Mint also has a constant growing demand for potassium during the growing season [8]. Potassium is known to play as essential role in enzyme activation, protein synthesis, photosynthesis, osmo-regulation, stomatal opening, energy transfer, cation-anion balance and stress resistance.

2. MATERIALS AND METHODS

The field experiment was conducted at the Norman E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, district U.S. Nagar (Uttarakhand) during spring season of 2017. Geographically, Pantnagar is situated at the foot hills of Himalayas at 29^0 North latitude and 79.5^0 East longitude and at an altitude of 243.83 m above mean sea level.

2.1 Cultural Operations

2.1.1 Land preparation

The field was prepared by two cross harrowings and one planking with the tractor mounted disc harrow. Thereafter, the field was leveled with leveler and layout was done.

2.1.2 Seed treatment and planting

Disease free healthy suckers were used for mint planting. Furrows were opened manually 40 cm apart. The suckers (4-5 cm length) @ 2 q/ha were placed in end to end fashion at a depth of 4 to 5 cm in furrows and covered immediately with fine loose soil. For seed treatment, suckers were treated with the mixture of Copper oxychloride and Thiram (2 g +1 g/ kg of suckers) before planting.

2.1.3 Drip installation

Drip laterals were installed in the field immediately after planting along the mint rows. Laterals were spaced at 40 cm row spacing.

2.2 Treatment Execution

2.2.1 Weed control

Pendimethaline @ 3.33 l/ha was applied as pre emergence to control the weeds. One manual weeding was also done at 26 days after planting to remove the left over weeds.

2.2.2 Insect pest control

The mint crop experienced a minor attack of shoot borer which was controlled by the application of Nuvan 76 SC @ 0.5 litre/ ha (380 g a.i./ ha) at 40 DAP.

2.2.3 Harvesting

The crop was harvested manually with a sickle by cutting at 5 cm above the ground level on 25th May, 2017 when lower leaves of the plant turned yellow and started shedding. After removing the border area, the individual net plot area (4.6 m^2) area was harvested.

2.2.4 Observation

Fresh herbage yield, Oil content, Oil yield, Economics-Cost of cultivation, Gross return, Net return, Benefit: Cost (B: C) and Energy use.

2.2.5 Variety

For mint cultivation, CIM Kranti, a high oil yielding variety was used. This variety has been developed through intensive selection at CIMAP. It has potential to produce 2.74 t/ha of herb with 0.84-1.0 % oil and the average oil yield is 265-290 kg/ha (CSIR Annual Report, 2009-10). Its oil contains 79-80% menthol.

3. RESULTS AND DISCUSSION

3.1 Fresh Herbage Yield

Fresh herbage yield increased significantly with increase in the depth of irrigation and it was recorded maximum with 125% CPE level. Drip irrigation in mentha at 125% CPE level recorded 18.2 and 6.8% higher fresh herbage yield than 75 and 100% CPE level of irrigation, respectively (Table 1). Irrigation schedule of 100% also produced 10.6% higher fresh herbage yield than 75% CPE level with a significant difference. The increase in herbage yield with higher levels of irrigation was closely associated with the beneficial effect of higher irrigation depth on plant height, number of leaves, leaf area index and dry matter accumulation. Actually the crop subjected to lower moisture regimes was incapable of fully exploiting the nutrient applied in the top soil. The roots under such conditions might have tended to penetrate deeper into the soil in quest of water and reduced root activity in the top soil layer might rendered lower nutrient uptake. Lower utilization of nutrients had resulted in reduced vegetative growth and herbage yield. Further, under better moisture regime, more mass flow and diffusion movement may be the cause of its better herbage yield. According to [9] in higher moisture regimes, the crop covered the ground at faster rate and developed sufficient photosynthetic area needed for maximum utilization of solar radiation which resulted in the higher herbage yield (Hamblin, 1985) reported that higher herbage yield at higher moisture regimes was due to more proliferation of root biomass resulting in higher absorption of nutrient and water from the soil leading to higher vegetative biomass [2] also reported that fresh herbage yields increased with increasing levels of irrigation. The favourable effect of irrigation in enhancing herb yield of menthol mint has also been reported by [1] and [10].

Fresh herbage yield also exhibited increasing trend with the increasing NPK levels. Mentha fertilized with 125% NPK level produced the maximum fresh herbage yield of 30027 kg/ha (Table 1). It was significantly superior to 75 and 100% NPK levels. The extent of increase in herbage yield was 24.9 and 5.1%, respectively. This might be due to adequate supply of nutrients increased herbage yield due to production of taller plants, more branches and leaves per plant, superior leaf-stem ratio and increased dry matter accumulation [11] also found higher fresh herbage yield with increasing the fertilizer dose over control.

3.2 Oil Content

A decreasing trend in oil content was observed with increase in moisture supply. Mint irrigated by flood method recorded the lowest oil content (0.87%) as illustrated in table no 1. Among the drip irrigation levels, it was found the highest (0.94%) at 75% CPE and the lowest at 125% CPE. The decline in oil content on the account of increased level of irrigation at 125% CPE (0.88) was significant against the drip irrigation of 75% CPE level and was at par with 100% CPE (0.89) drip irrigation level (Table 1). The reduction in oil content with increase in irrigation level might be attributed to increased crop growth, which caused greater senescence of lower leaves due to mutual shading and resulted into reduction in leaf to stem ratio. Under better moisture supply, the leaf: stem was lowered down resulting in reduced oil content because leaves are the principles sites for oil production.

Crop fertilized with 125% NPK level recorded the highest and significantly higher oil content (0.92%) than lower doses of NPK levels (Table 1). The differences between 75 and 100% NPK levels for the oil content was found non-significant. The lowest oil content was recorded with 75% NPK level. It might be due to role of nitrogen which plays an important role in plant growth and development. It promotes vegetative growth through cell enlargement, multiplication and increase in the rate of photosynthesis. Application of adequate amount of phosphorus helps in ramification of the root system, which increased the number of suckers in the plant. More sucker production resulted in higher herbage and oil yield. Further, it might be due to more vegetative growth at higher nutrient levels resulting in accumulation of metabolites toform more oil.

3.3 Oil Yield

Irrigation scheduling exerted significant effect on oil yield of menthol mint. Oil yield showed an increasing trend with increased level of irrigation being the maximum at 125% CPE drip irrigation level as given in Table 1. Flood irrigated mint crop recorded the lowest oil yield (171 kg/ha). The lowest oil yield in this treatment was due to its lower fresh herbage yield as well as its lower oil content. Drip irrigation at 125% level recorded the maximum oil yield but it was comparable with 100% CPE level. Former treatment recorded significantly higher oil yield than 75% CPE level.

The oil yield is the function of fresh herbage yield and oil content. In spite of having lower oil content, 125% CPE level produced the maximum oil yield owing to its higher fresh herbage yield (Table 1). Higher moisture in the soil resulted in reduction in oil content but because of better plant growth in terms of plant height, more stool count, fresh herbage yield at higher irrigation level ultimately resulted in higher oil yield. The difference between 75 and 100% CPE levels for oil yield was not enough to be significant. Behera *et al*., 2013 also recorded increase in oil yield in the mint due to adequate availability of moisture to the crop.

Increase in fertilizer dose from 75% to 125% NPK resulted in significant improvement in oil yield. Drip fertigation with 125% NPK recorded the maximum oil yield (274 kg/ha) (Table 1). It produced significantly higher oil yield than 75% and 100% NPK levels with a difference of 28.6 and 7.5%, respectively. Mint fertigated with 100% NPK levels recorded 19.7% higher oil yield than75% NPK levels. Higher mint oil yield with higher doses of NPK was due to its higher herbage oil yield as well as its higher oil content [7] also found significantly higher oil yield with 100% of RDF fertigation schedule as compared to 75% and 50% of RDF.

Table 1. Herbage yield, oil content and oil yield of mint at harvest as influenced by drip irrigation CPE and NPK levels

Treatment	Herbage yield (kg/ha)	Oil content (%)	Oil yield(kg/ha)
Drip irrigation level (CPE)			
75% CPE	25130	0.94	236
100%CPE	27804	0.89	247
125% CPE	29699	0.88	260
SEm ±	464	0.004	4.3
CD (5%)	1404	0.012	13.1
$N:P_2O_5:K_2O$ dose (100:60:40 kg/ha)			
75% NPK	24044	0.89	213
100% NPK	28561	0.90	255
125% NPK	30027	0.92	274
SEm ±	464	0.004	4.3
CD (5%)	1404	0.012	13.1
Control			
Flood (1.0 IW:CPE ratios)	19567	0.87	171

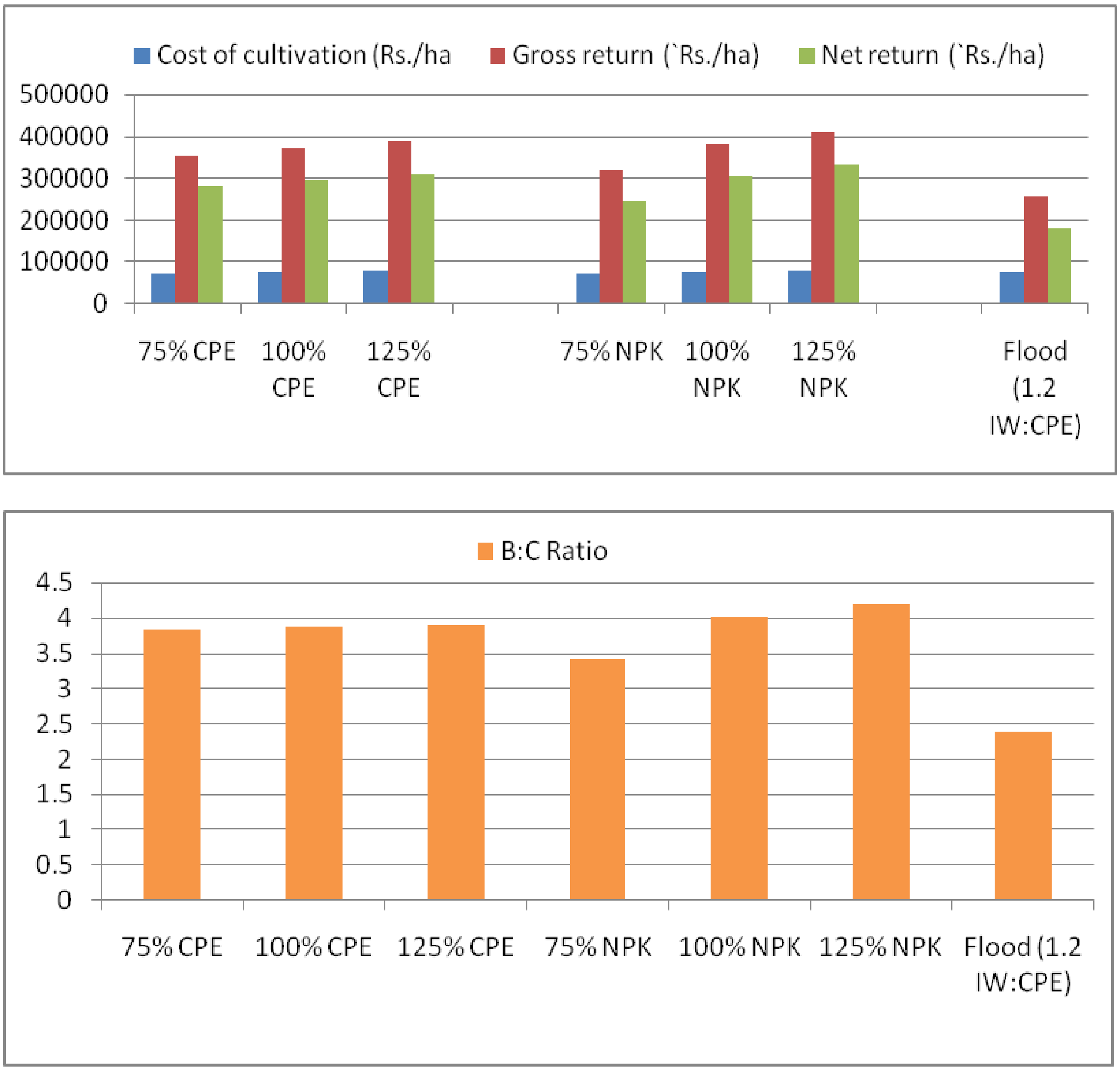

Fig. 1. Mint economics under different drip irrigation level and fertilizer level

3.4 Economics

3.4.1 Cost of cultivation

As illustrated figure in 1, economics revealed that the maximum cost of cultivation was incurred when drip irrigation at 125% CPE level. It was higher by Rs.7535/ha and Rs. 3131/ha compared to 75 and 100% CPE levels, respectively. Also, it was Rs. 4241/ha costlier than surface flood method. The higher cost spend in 125% CPE drip irrigation was due to extra cost incurred on account of more number of irrigations and higher cost for oil extraction because of its higher herbage yield. Drip irrigation at 75% CPE level required Rs. 3294/ha less money as compared to surface flood method of irrigation. The lowest cost of cultivation at 75% CPE drip level was due to low water applicationin this treatment.

Fig. 1 showed that the cost of cultivation of mentha was also increased with increasing the NPK dose being the highest at 125% NPK level (Rs. 79178/ha). It was due to higher cost incurred on fertilizers [12] also observed higher cost of cultivation due to increased level of irrigation.

3.4.2 Gross return

The highest gross return was received from the 125% CPE drip irrigation level (Fig. 1). It gave 52.1% higher gross return than flood irrigated mint crop because of higher mint oil yield. Among the drip irrigation levels, 125% CPE drip level gave Rs. 36492 and 19868 more gross return than 75% and 100% CPE levels, respectively. The results are in accordance with the findings of [9]. They reported 17.4 and 5.9% higher gross returns due to irrigation at 100% CPE over 60 and 80% CPE, respectively. Among the nutrient schedules, 125% of NPK dose provided the maximum gross return (Rs. 411, 429/ha) and it declined significantly with reduction in the NPK dose. Higher gross return at higher drip irrigation and NPK levels was because of higher oil yield, under these treatments.

3.4.3 Net return

Fig. 1 indicated that irrespective of any drip irrigation level, drip irrigated mint crop gave higher net return than flood irrigated mint crop. Among the drip irrigation levels, irrigation scheduled at 125% CPE level gave the maximum net return (Rs. 310730/ha). It was comparable with 100% CPE level but fetched significantly higher net return than 75% CPE level. The lowest net returns of Rs. 280517/ha was obtained with 75% CPE level. Higher net return at 125% CPE level was because of its higher gross return. Among the NPK levels, mint fertilized with 125% recommended dose of NPK gave the maximum net return (Rs. 332,357/ha) (Fig. 1). It was significantly higher by Rs. 26319 and Rs. 85297/ha than 100% and 75% NPK levels, respectively. Behera *et al*. [10] found that mint irrigated at 100% CPE level gave 17.4 and 5.9% higher net return than 60 and 80% CPE, respectively. Higher net return at higher drip irrigation and NPK levels was because of higher oil yield which fetched more gross return. The reason cited for higher gross return also holds true for the net return.

3.4.4 Benefit: Cost (B:C)

Fig. 1 sowing that irrespective of any drip irrigation level, drip irrigated mint crop gave higher B: C than flood irrigated mint crop. The B to C ratio remained statistically unchanged due to drip irrigation levels. It showed significant variations due to NPK dose only. Drip irrigation at 125% CPE level gave numerically higher value of B: C (3.90) than 75 and 100% CPE levels [10] also noted higher B:C ratio at higher moisture regimes. Crop fertilized with 125% dose of NPK recorded the maximum B: C (4.20). It was at par with 100% NPK dose but gave significantly 23.2% higher B: C than 75% NPK dose.

3.5 Energy Use Parameters

Total energy input increased with increase in irrigation depth and NPK dose, being 18674 and 18383 MJ/ha, respectively at 125% CPE and 125% NPK levels (Table 2). All the drip treatments required lower input energy than control flood (22349 MJ/ha).

Total output energy at 125% CPE increased significantly over 75% and 100% CPE (increase of 5.4%). Energy use efficiency and energy productivity decreased with increase in irrigation levels. Both these parameters did not differ significantly between 75 and 100% CPE levels but 75% CPE level recorded significantly higher values than 125% CPE (Table 2). Energy intensiveness and net energy gain (MJ/ha) increased with irrigation levels. Drip irrigation level 125% recorded energy intensiveness of 0.24 MJ/Rs and 33604 MJ/ha net energy. The increase in net energy with 125% CPE was 3.7 and 5.3%, respectively over 100 and 75% CPE.

Table 2. Energy use parameter of mentha under different drip irrigation and nutrient levels

Treatment	Total input energy(MJ/ha)	Total output energy (MJ/ha)	Energy use efficiency	Energy intensiveness (MJ/Rs)	Energy productivity (Kg/MJ)	Net energy gain(MJ/ha)
Drip irrigation level (CPE)						
75% CPE	15177	47364	3.06	0.21	0.015	31912
100% CPE	16925	49339	2.91	0.22	0.015	32396
125% CPE	18674	51988	2.82	0.24	0.014	33604
SEM±	-	860	0.05		0.000	860
CD at 5%	-	2600	0.16		0.001	NS
$N:P_2O_5:K_2O$ dose (100:60:40 kg/ha)						
75% NPK	15451	42611	2.81	0.21	0.014	27434
100% NPK	16942	50980	3.02	0.22	0.015	34054
125% NPK	18383	55099	2.96	0.23	0.015	36425
SEM±		860	0.05		0.000	860
CD at 5%		2600	0.16		0.001	2600
Control						
Flood (1.2 IW:CPE)	22349	34185	1.53	0.30	0.008	11836

Table 3. Price of different inputs and output

Operation	Cost (Rs.)
Harrowing (Rs./ha)	750
Planking (Rs./ha)	375
Suckers (Rs./q)	5000
Blitox + Bavistin	100
Tractor (Rs./hr)	600
Labour cost (Rs./labour)	225
NPK mixture (Rs./50 kg)	1038.5
Urea (Rs./50 kg)	298
MOP (Rs./50 kg)	800
Pendimethalin (Rs./l)	400
Nuvan insecticide (Rs./l)	500
Irrigation (Rs./irrigation)	750
Oil extraction (Rs./kg)	100
Drip irrigation (Rs./cm)	100

Table 4. Input energy used under different treatments in Mentha

Input energy	Total energy (MJ/ha)			
	Control	**75%**	**100%**	**125%**
Human labour	1138.14	948.49	976.37	1001.67
Machinery	337.28	337.28	337.28	337.28
Diesel fuel	2540.62	2540.62	2540.62	2540.62
Chemical Fertilizer				
a. Nitrogen	6060	4545	6060	7575
b. Phosphorus	666	499.5	666	832.5
c. Potassium	268	201	268	335
Chemical		5245.5	6994	8742.5
a. Herbicide	301.2	301.2	301.2	301.2
b. Pesticide	50	50	50	50
c. Fungicide				
Water for irrigation	7742	4067	5452	6801
Total	**19103.24**	**13490.09**	**16651.47**	**19774**

Total output energy increased with increase in fertilizer level from 75 to 125%. The energy use efficiency was the highest with 100% NPK (3.02), which was significantly superior to 75% NPK, but were at par with 125% NPK (2.96) (Table 2). Energy intensiveness increased with increased levels of fertilizer being maximum (0.23) at 125% NPK level.

Energy productivity and net energy increased with increase in NPK level. Energy productivity was significantly higher at 125% NPK than 75% NPK but was at par with 100% NPK. Similar trend was noted for net energy gain where 125% NPK level being at par with 100% NPK recorded significantly higher value than 75% NPK. Energy parameter viz. totals output energy, energy use efficiency, energy productivity and net energy was found lower in surface flood method as compared to drip fertigationtreatment.

4. CONCLUSION

From the results of present investigation, it is concluded that 125 % Drip irrigation level (CPE) with 125 % NPK dose (100:60:40) gave better performance in parameters like Fresh herbage yield, Oil content, Oil yield. Economics, Net return, Benefit: Cost (B: C) and total output energy were observed found effective with respect superior in enhancing parameters. Therefore, it may be recommended that mentha crop could be drip irrigate at 100% CPE at 2 days frequency and fertilize with 125:75:50 kg NPK/ha.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Shormin T, Khan MAH, Alamgir M. Response of different levels of nitrogen fertilizers and water stress on the growth and yield of mint. Bangladesh Journal of Science and Industrial Research. 2009;44(1):137–145.
2. Ram M, Ram D, Singh S. Irrigation and nitrogen requirements of bergamot mint on a sandy loam soil under sub-tropical conditions. Agricultural Water Management. 1995;27(1):45-54.
3. Mengel K, Kirkby EA. Principles of plant nutrition. (4th ed.) Panama Publishing Corporation. New Delhi, India; 1996.
4. Patra DD, Ram M, Singh DV. Influence of straw mulching on fertilizer nitrogen use efficiency, moisture conservation and herb and essential oil yield in *Japanese* mint (*Mentha arvensis* L.). Fertilizer Research. 1993;34(3):135-139.
5. Li JJ, Zhang R. Water and nitrogen distribution as affected by fertigation of ammonium nitrate from a point source. Journal of Irrigation Science. 2003;22(4):19-30.
6. Behera MS, Mahapatra PK, Singandhupe RB, Kannan K. Fertigation studies in mint (*Mentha arvensis* L.) under humid climate in Odisha, India. African Journal of Agricultural Research. 2015;10(11):1320-1330.
7. Behera MS, Mahapatra PK, Singandhupe RB, Kundu D, Kannan K, Mandal K, Singh A. Effect of drip fertigation on yield, water use efficiency and water productivity of mint (*Mentha arvensis* L.). Journal of Agricultural Physics. 2014;14(1):37-43.

8. Browm B, Hart JM, Wescott MP, Christensen NW. The critical role of nutrient management in mint production. Better Crops. 2003;87(4):9-11.
9. Saxena A, Singh JN. Yield and nitrogen uptake of Japanese mint (*Mentha arvensis*) under various moisture regimes, mulch application and nitrogen fertilization. Journal of Medicinal and Aromatic Plant Sciences. 1996;18: 477-480.
10. Behera MS, Verma OP, Mahapatra PK, Singandhupe RB, Kumar A. Effect of irrigation and fertility levels on yield, quality and economics of mint (*Mentha arvensis*) under drip irrigation system. Indian Journal of Agronomy. 2013;58(1):109-113.
11. Anwar M, Chand S, Patra DD. Effect of graded level of NPK on fresh herb yield, oil yield and oil composition of six cultivars of menthol mint. Indian Journal of Natural Products and Resources. 2010;1(1):74-79.
12. Nakawuka P, Peters TR, Gallardo KR, Gonzalez DT, Okwany RO, Walsh DB. Effect of deficit irrigation on yield, quality and costs of the production of native spearmint. Journal of Irrigation and Drain Engineering. 2014;20(5):140-149.

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