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Effect of nitrogen and cow dung on the growth of kalmegh (*Andrographis paniculata*)

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Abstract

Kalmegh (*Andrographis paniculata*) is a well-known multifaceted medicinal plant used in both *Ayurvedic* and *Unani* system because of its immunological, antibacterial and hepatoprotective properties. A pot experiment was carried out to evaluate the response of kalmegh to various combinations of nitrogen and cowdung. There were 16 treatment combinations in the experiment comprising four levels of N (0, 20, 40, and 60 kg/ha) and four levels of cowdung (0, 15, 30, and 45 % cowdung on volume basis). Regarding growth parameters, the main and interaction effects of cowdung and nitrogen on plant height, number of leaf and branch per plant were created significant positive impacts. The highest plant height (66.60cm) was recorded from the highest combination of cowdung and N treatment ($C_{45}N_{60}$) followed by $C_{30}N_{60}$ treatment. The shortest plant (42.88cm) was found from the treatment, which received no cowdung and N fertilizer. Similarly the highest dry yield per plant of (74.8g) was noted from the highest combined application of $C_{45}N_{60}$. Regression analysis showed highly significant linear response of total plant yield to both cowdung and nitrogen level. Alternatively, regression analysis showed negative relationship between root dry weight and levels of cowdung and nitrogen throughout the growing period. Nitrogen content of kalmegh also showed similar responses where plant nitrogen content (3.26%) was the highest in the combined application of $C_{45}N_{60}$. The study revealed that, combination of 45% cowdung and 60 kg N/ha was considered to be the optimum level of cowdung and nitrogen for achieving the maximum growth and yield of kalmegh.

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Introduction

In Bangladesh, medicinal plants are found to grow naturally in the forest, bushes and marginal land along the canal and in other places. There are about 5000 species of plants growing in Bangladesh; among them 650 species are having medicinal properties (Ghani, 2000; Dixie *et al.*, 2003). Many such medicinal plants especially the aromatic herbs are grown in the home garden or as crop field either as sole cropping system or rarely as plantation crop (Padua *et al.*, 1999). But due to the lack of organized and scientific cultivation, proper management, and awareness of social factors, the number of these plants is decreasing at an alarming rate.

Kalmegh (*Andrographis paniculata*) is an important medicinal plant known as "King of Bitters" and belongs to Acanthaceae family. It grows abundantly in Southeast Asian countries such as Sri Lanka, Pakistan, Malaysia, Bangladesh, Indonesia and has been cultivated extensively for medicinal purpose in India, China, Thailand, East and West Indies (Chandni *et al.*,2015;Joseph and Jeeva, 2010). It is well-known multifaceted plant for having phytochemical andrographis; which is an excellent immune system enhancer and in the treatment of fevers, worms, dysentery and also useful for children suffering from liver and digestive complaints (Chandni *et al.*,2015).

In Bangladesh, household medicine known as Aluii is made from the leaves of kalmegh and is given to children suffering from stomach complaints. Kalmegh is also reported to possess anti-hepatotoxic, antibiotic, antimalarial, antihepatitic, antithrombogenic, anti-inflammatory, anti-snakevenom, and antipyretic properties (Gupta *et al.*, 1990). It also acts anti-HIV activity of andrographolide. Andrographolide treatment inhibited the in vitro proliferation of different tumor cell lines, representing various types of cancers (Sharma, 2004). However, existing populations of kalmegh are diminishing. Hence, according to new International Union for Conservation of Nature and Natural resources (IUCN) criteria, kalmegh has been categorized as critically endangered species (Kerry and Gillett, 1997). This leads to a need for conservation of the plant.

The aforementioned statements highlighted that kalmegh has high medicinal and economic value across the globe including Bangladesh. This medicinal plant enjoys a good domestic and international market. Considering the medicinal and economic values efforts should be given to maximize the production of kalmegh.

The soil and climatic condition of Bangladesh are favorable for the cultivation of kalmegh. These opportunities could be used to meet the domestic and international demand.

There are many ways to increase the yield per unit area; management practice is one of the better options. Fertilizer management is the key factor in the management practices.

Therefore, there is a need to standardized fertilizer combinations that would favorably influence on the growth and yield of kalmegh. Keeping this view in mind, the study was undertaken to assess the effect of nitrogenous fertilizer and cowdung on growth and yield of kalmegh as well as to determine the optimum fertilizer level for kalmegh cultivation.

Materials and methods

Experimental site

A pot experiment was designed at the research field of the Department of Agroforestry and Environment (24° 09` N; 90° 26` E) Gazipur, during the period from April to October, 2017. The minimum and maximum temperatures of the research area were fluctuated between 22 to 33°C and 15 to 28°C, respectively, during the experimental period.

The mean annual rainfall of the area is about 2200 mm of which 78 to 92% occurs during April through September covering the early kharif to late kharif seasons causing occasional short flooding or runoff of excess water.

Planting material

Seeds of kalmegh were used as propagation materials. The seeds were collected from Bangladesh Rural Advancement Committee (BRAC) farm, Gazipur. Seeds were sown on March 22, 2017.

The seed bed was prepared in a tray for raising seedlings using soil and decomposed cowdung in 1:1 ratio. Seeds were sown in tray and covered immediately with newspaper. Complete germination of seeds took place within five days.

Design of experiment

The experiment was laid out in a Completely Randomized Design (CRD) with five replications. There were 16 treatment combinations in the experiment comprising four levels of nitrogen (N) (0, 20, 40, and 60 kg/ha) and four levels of cowdung (0, 15, 30, and 45 % cowdung on volume basis).

The treatment combinations used in the experiment are shown in Table 1.

Potting of soil

The soilused in the experiment belongs to Kodda series under Madhupur Tract (AEZ 28). Pots used in this experiment were uniform in size and filled with soil and cowdung up to a certain level. When pots received 0% cowdung, then these were filled with 12 kg soil. For the treatment of 15% cowdung, soil and cowdung were mixed at a ratio of 5.6:1 i.e., 10.2 kg soil and 1.8 kg cowdung per pot. Similarly the treatment of 30% and 45% cowdung, soil and cowdung were mixed at a ratio of 2.3: 1 and 1.2: 1, respectively.

Fertilization

Full amount of TSP and MP @ 0.455 (15 kg P ha^{-1}) and 0.486 g (20 kg K ha^{-1}) per pot, respectively, were added to the soil of each pot during seedling transplantation. Urea was top dressed in three equal installments at 15, 45 and 90 days after transplanting. Each unit pot received 0.211, 0.42 and 0.63 g urea per installment, where it was applied at a rate of 20, 40 and 60 kg N/ha, respectively.

Transplantation of seedling

Twenty eight days oldhealthy seedlings were transplanted in pots on 20th April, 2017. The pots were watered regularly to reduce mortality rate of transplanted seedlings. After establishment of the kalmegh plants in pots, weeding was done at 25, 50, 75, 100 and 150 days after transplant. A systemic acariside “Tolester” was sprayed one time @ 1.5 ml/L to control ants.

Data collection

Harvesting was initiated on October 20, 2017 and completed on October 24, 2017. The Plant height, number of branch per plant, number of leaf per plant, fresh weight of leaf per plant, dry weight of leaf per plant, fresh weight of branch per plant, dry weight of branch per plant, fresh weight of root per plant, dry weight of root per plant, fresh yield per plant, dry yield per plant were measured during data collection.

Measurement of plant N content

Total nitrogen content in plant samples (leaf, branch and root) was determined by Micro-Kjeldahl method following Selicylic-H_2SO_4 digestion (Yamakawa, 1993) through calorimetric method. Nitrogen was measured by using double beam spectrophotometer (Model no. 200-20, Hitachi, Japan) at 625-nm wavelength.

Statistical analysis

Standard statistical procedure was used to analyze the data obtain from the experiment using MSTAT computer software to examine the significant variation of the results due to different treatments. The treatment means were compared by DMRT at 5% level of significance (Gomez and Gomez, 1984).

Results and discussion

Plant height

Plant heightis an important component thathelps to determine plant growth. Plant height of kalmeghat maturity stage was significantly influenced by different N and also by different cowdung levels (Table 2). In general, plant height increased with the increasing rate of cowdung application and the highest plant height of kalmegh was recordeds

eparately from the treatment of 45% cowdung (63.78 cm) and 60 kg N ha^{-1} (61.20 cm) applied plot. In contrast, the shortest plant height (47.57cm and 55.23cm) was noted from the treatment, which received no cowdung and N fertilizer, respectively. Higher amount of nitrogen application hadled to better vegetative growth of plants thatled to attain the highestheight. Result of the present study is also supported by the findings of Gasim (2001) whoob served that addition of nitrogen fertilizer increased plant height.

Table 1. Treatment combinations used in the experiment.

Treatment combination	Nitrogen (kg/ha)	Cowdung (% of soil volume)	Cowdung (kg/pot)
C_0N_0 (Control)	0	0	0
C_0N_{20}	20	0	0
C_0N_{40}	40	0	0
C_0N_{60}	60	0	0
$C_{15}N_0$	0	15	1.8
$C_{15}N_{20}$	20	15	1.8
$C_{15}N_{40}$	40	15	1.8
$C_{15}N_{60}$	60	15	1.8
$C_{30}N_0$	0	30	3.6
$C_{30}N_{20}$	20	30	3.6
$C_{30}N_{40}$	40	30	3.6
$C_{30}N_{60}$	60	30	3.6
$C_{45}N_0$	0	45	5.6
$C_{45}N_{20}$	20	45	5.6
$C_{45}N_{40}$	40	45	5.6
$C_{45}N_{60}$	60	45	5.6

(C_0= 0% cowdung, C_{15}= 15 % cowdung, C_{30}= 30% cowdung, C_{45}= 45% cowdung, N_0= 0 kg N/ha, N_{20}= 20 kg N/ha N_{40}= 0 kg N/ha, N_{60}= 60 kg N/ha).

The interaction effect of cowdung and N also significantly improved the plant height of kalmegh (Table 3). The highest plant height (66.60cm) was recorded from the highest combination of cowdung and N treatment ($C_{45}N_{60}$) followed by 30% cowdung and 60 kg N ha^{-1} treatment ($C_{30}N_{60}$).

The shortest plant (42.88cm) was found from the treatment, which received no cowdung and N fertilizer. However, staticallyidentical plant height was observed from the treatment combination of $C_{15}N_{60}$, $C_{30}N_0$, $C_{30}N_{20}$, $C_{45}N_0$ and $C_{45}N_{20}$. The increase plant height of kalmegh altered with cow dung and N ismaybe due to release of nutrients which promoted vigorous plant growth through efficient photosynthesis (Iqtidar *et al.*, 2006). As well as, an optimum plant heightisasserted to be positively correlated with productivity of plants (Saeed *et al.*, 2001).

Number of branch per plant

Number of branches per plant of kalmegh grown under different cowdung and N levels varied significantly (Table 2).

The highest number of branches per plant (40.10) was found at 45% cowdung applied treatment. Moreover, the maximum number of branches per plant (40.20) was recorded in 60 kg N ha^{-1} applied treatment followed by 40 kg N ha^{-1} applied treatment,

which was statistically similar to each other. However, significantly the lower number of branches per plant was observed at no cowdung and N applied treatment compared to the other treatments. The positive effect of N on pea and ashwagandha were also reported by Negi (1992) and Singh (2005), respectively.

Table 2. Main effect of cowdung and N levels on different plant characters of kalmegh.

Treatment	Plant height (cm)	Branch per plant(Number)	Leaf per plant(Number)
Cowdung dose (%)			
0	47.57 d	32.80 c	1672.80 c
15	57.95 c	37.75 b	1925.25 b
30	62.70 b	38.05 b	1990.55 a
45	63.78 a	40.10 a	2045.10 a
Nitrogen dose (kg/ha)			
0	55.23 d	33.30 c	1698.30 d
20	56.69 c	36.55 b	1864.05 c
40	58.88 b	38.65 a	1971.15 b
60	61.20 a	40.20 a	2100.20 a
CV%	2.46	6.92	5.06

Results followed by same letters are not significantly different from each other at 5% level of significance by DMRT.

It was also observed that the highest combination of cowdung and N ($C_{45}N_{60}$) significantly produce the highest number of branches per plant (43.80) of kalmegh (Table 3), which was identical with the combination of $C_{45}N_{40}$. On the other hand, the lowest number of branches per plant was noted from control. The increase in number of branches per plant with increase in N rate could be explained that N promoted vegetative growth and branching on the inflorescence. These results agree with those documented by Uddin *et al.* (1992), who reported that number of branches per plant considerablely increased with N doses from 0 to 150 kg ha^{-1}.

Table 3. Interaction effect of cowdung and N levels on different plant characters of kalmegh.

Cowdung dose (%)	Nitrogen dose (kg/ha)	Plant height (cm)	Branch per plant (Number)	Leaf per plant (Number)
0	0	42.88 i	22.80 g	1162 e
	20	46.25 h	34.60 f	1764 d
	40	48.75 g	35.60 ef	1815 cd
	60	52.40 f	38.20 bcde	1948 bc
15	0	55.90 e	36.00 def	1836 cd
	20	56.85 de	36.60 cdef	1866 bcd
	40	58.05 d	38.80 bcde	1978 b
	60	61.00 c	39.60 bc	2019 b
30	0	60.50 c	37.00 cdef	1887 bcd
	20	61.50 c	37.20 cdef	1897 bcd
	40	64.00 b	38.80 bcde	1978 b
	60	64.80 ab	39.20 bcd	2199 a
45	0	61.65 c	37.40 cdef	1907 bc
	20	62.15 c	37.80 cdef	1927 bc
	40	64.70 b	41.40 ab	2111 a
	60	66.60 a	43.80 a	2233 a
CV%		2.46	6.92	5.06

Results followed by same letters are not significantly different from each other at 5% level of significance by DMRT.

Number of leaf per plant

The main effect of different levels of cowdung and N on the number of leaves per plant was found significant (Table 2). The maximum number of leaves per plant, specifically 2100 and 2045 were observed in the treatment where individually applied 45% cowdung and 60 kg N ha^{-1}, respectively. The minimum number of leaves per plant was found from the treatment where no cowdung (1672) and N (1698) was applied. This positive effect of N on number of leaves per plant was also reported by Melton and Dufault (1991) and Amin (2011) in tomato and maize, respectively.

Table 4. Main effect of cowdung and N levels on the leaf, branch and root dry weight of kalmegh.

Treatment	Leaf dry weight Per plant (g)	Branch dry weight per plant (g)	Root dry weight per plant (g)
Cowdung dose (%)			
0	21.05 c	25.58 c	4.24 a
15	24.25 b	37.25 b	2.85 b
30	24.55 ab	40.08 a	2.15 c
45	25.07 a	41.64 a	2.11 c
Nitrogen dose (kg/ha)			
0	21.22 d	32.42 d	3.15 a
20	23.20 c	34.37 c	2.94 b
40	24.59 b	36.80 b	2.68 c
60	25.91 a	40.97 a	2.58 c
CV%	5.97	7.01	8.17

Results followed by same letters are not significantly different from each other at 5% level of significance by DMRT.

Table 5. Interaction effect of cowdung and N levels on the leaf, branch and root dry weight of kalmegh.

Cowdung dose (%)	Nitrogen dose (kg/ha)	Leaf dry weight per plant (g)	Branch dry weight per plant (g)	Root dry weight/plant (g)
0	0	15.05 f	20.38 h	4.84 a
	20	22.03 e	21.18 h	4.41 b
	40	23.25 de	24.88 g	4.00 c
	60	23.88 cd	35.90 ef	3.71 c
15	0	23.30 de	34.06 f	3.29 d
	20	23.88 cd	36.42 ef	3.11 d
	40	24.49 bcd	39.00 cde	2.58 e
	60	25.32 bc	39.54 bcde	2.42 ef
30	0	23.13 de	37.22 def	2.24 fg
	20	23.25 de	39.27 cde	2.21 fg
	40	24.73 bcd	40.87 bcd	2.01 g
	60	27.07 a	42.98 ab	2.15 fg
45	0	23.38 de	38.01 de	2.23 fg
	20	23.63 cde	40.62 bcd	2.04 g
	40	25.88 ab	42.47 abc	2.12 fg
	60	27.38 a	45.46 a	2.03 g
CV%		5.97	7.01	8.17

Results followed by same letters are not significantly different from each other at 5% level of significance by DMRT.

The combined effect of different levels of cowdung and N on the number of leaves per plant was statistically significant (Table 3). In general, the highest number of leaves per plant (2233) was recorded from the highest combined application of $C_{45}N_{60}$ which was identical with the combined application of $C_{45}N_{40}$ and $C_{30}N_{60}$. On the other hand, significantly the lowest number of leaves per plant was observed in control.

Table 6. Main effect of cowdung and N levels on percent N content, total plant fresh and dry yield of kalmegh.

Treatment	Nitrogen content(Percent)	Total plant fresh yield (g/ plant)	Total plant dry yield (g/ plant)
Cowdung dose (%)			
0	1.67 d	199.20 c	50.88 d
15	2.56 c	226.09 b	64.35 c
30	2.84 b	230.70 b	66.78 b
45	3.16 a	239.44 a	68.81 a
Nitrogen dose (kg/ha)			
0	2.37 c	201.51 d	56.78 d
20	2.53 b	219.25 c	60.51 c
40	2.63 ab	232.41 b	64.07 b
60	2.70 a	242.25 a	69.46 a
CV%	3.16	3.99	4.92

Results followed by same letters are not significantly different from each other at 5% level of significance by DMRT.

Leaf dry weight

The main effect of cowdung on leaf dry weight of kalmegh was statistically significant (Table 4). The highest leaf dry weight (25.07g) was obtained from 45% cowdung applied treatment which was statistically similar to leaf dry weight obtained from 30% cowdung applied treatment (24.55g). But both values were different from no cowdung applied treatment which produced the lowest leaf dry weight (21.06g) (Table 4). In case of N, leaf dry weight was increased with the increasing rate of N. These results were in close consonance with the observation of Hokmalipour and Darbandi (2011) in maize.

Table 7. Interaction effect of cowdung and N levels on percent N content, total plant fresh and dry weight of kalmegh

Cowdung dose (%)	Nitrogen dose (kg/ha)	Nitrogen content(Percent)	Total plant fresh yield (g/ plant)	Total plant dry yield(g/ plant)
0	0	1.34 k	145.47 i	40.28 I
	20	1.63 j	209.30 h	47.61 h
	40	1.81 I	213.49 gh	52.13 g
	60	1.89 I	228.55 def	63.49 def
15	0	2.39 h	215.03 gh	60.65 f
	20	2.54 g	219.28 fgh	63.40 def
	40	2.62f g	233.18 cde	66.06 de
	60	2.68 efg	236.86 cd	67.28 cd
30	0	2.71 ef	221.82 efgh	62.59 ef
	20	2.83 de	222.41 efg	64.74 def
	40	2.88 d	233.76 cde	67.61 cd
	60	2.94 cd	244.80 bc	72.19 ab
45	0	3.06 bc	223.73 efg	63.62 def
	20	3.12 ab	225.99 defg	66.29 cde
	40	3.21 ab	249.22 ab	70.47 bc
	60	3.26 a	258.79 a	74.87 a
CV%		3.17	3.99	4.92

Results followed by same letters are not significantly different from each other at 5% level of significance by DMRT.

The interaction effect of different cowdung and N levels was significant in producing leaf dry weight of kalmegh (Table 5). The highest leaf dry weight (27.38g) was recorded from the highest combined application of $C_{45}N_{60}$ which was identical with the combined application of $C_{45}N_{40}$ and $C_{30}N_{60}$. These results revealed that application of organic fertilizers probably increased nitrogen in the soil which positively influenced leaf fresh weight and quality of the leaves. Since, nitrogen arouses plant vegetative growth and increases leaf area; as a result increment in the leaf area increases the rate of plant photosynthesis. Thus higher leaf quality and leaf weight (Reyhan and Amisalani, 2006).

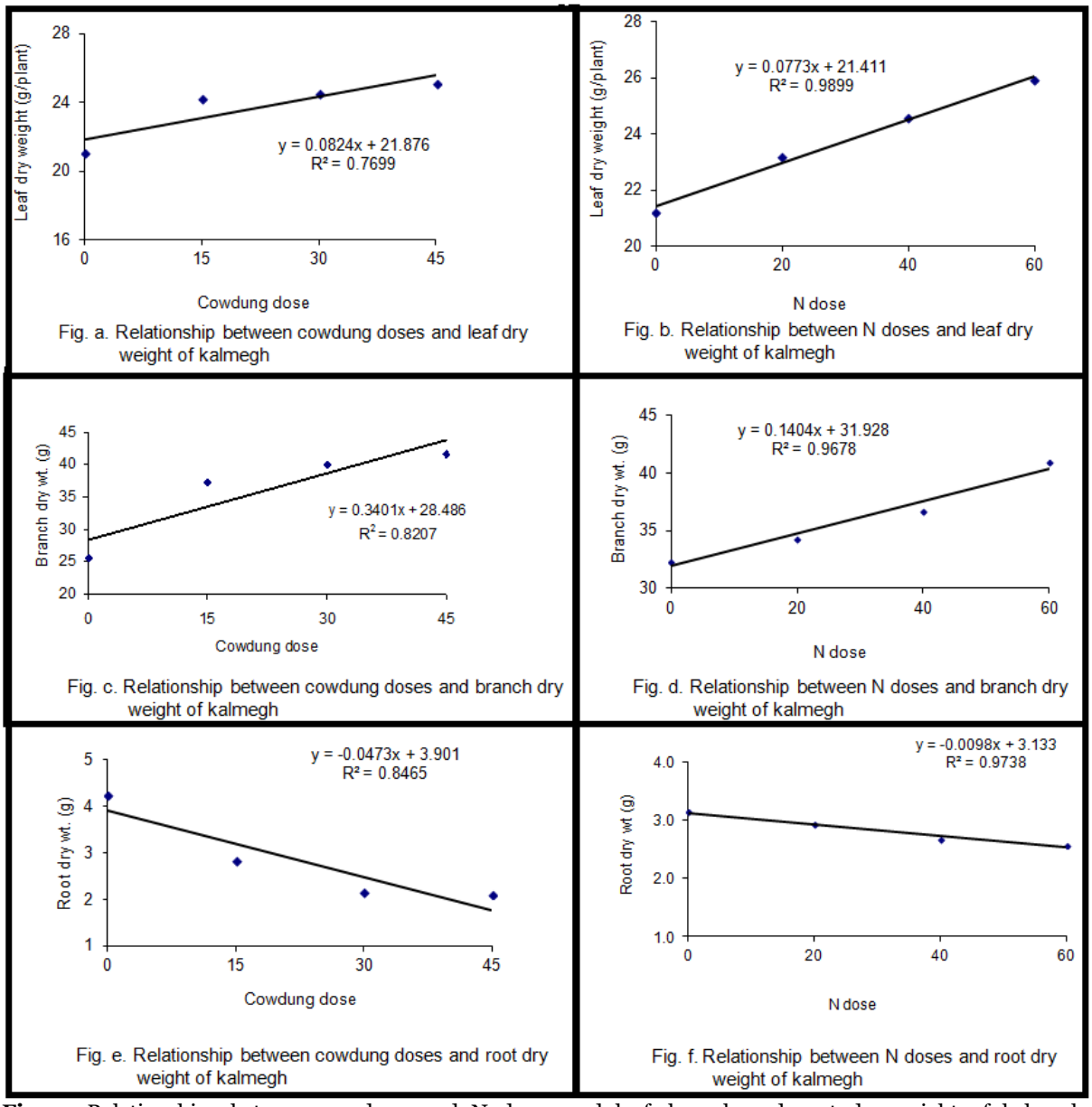

Fig. 1. Relationships between cowdung and N doses and leaf, branch and root dry weight of kalmegh.

Branch dry weight

The highest branch dry weight (41.64g) was obtained from 45% cowdung applied treatment, which was statistically similar at 30% cowdung applied treatment (40.08g) but values of both treatments were different from no cowdung applied treatment that produced the lowest branch dry weight (25.58g) (Table 4). In case of N, the highest branch dry weight of kalmegh (40.97g) was found from 60 kg N ha^{-1} applied treatment. Mosarref *et al.*, (2015) reported that different levels of nitrogen showed significant

differences in dry matter yield of mung beanup to a certain level (60 kg N ha^{-1}).

The interaction effect of different cowdung and N levels in producing branch dry weight of kalmegh was significant (Table 5). The highest branch dry weight (45.46 g) was recorded from the highest combined application of $C_{45}N_{60}$ followed by $C_{45}N_{40}$ (42.47 g); and $C_{30}N_{60}$ which was statistically similar to each other.

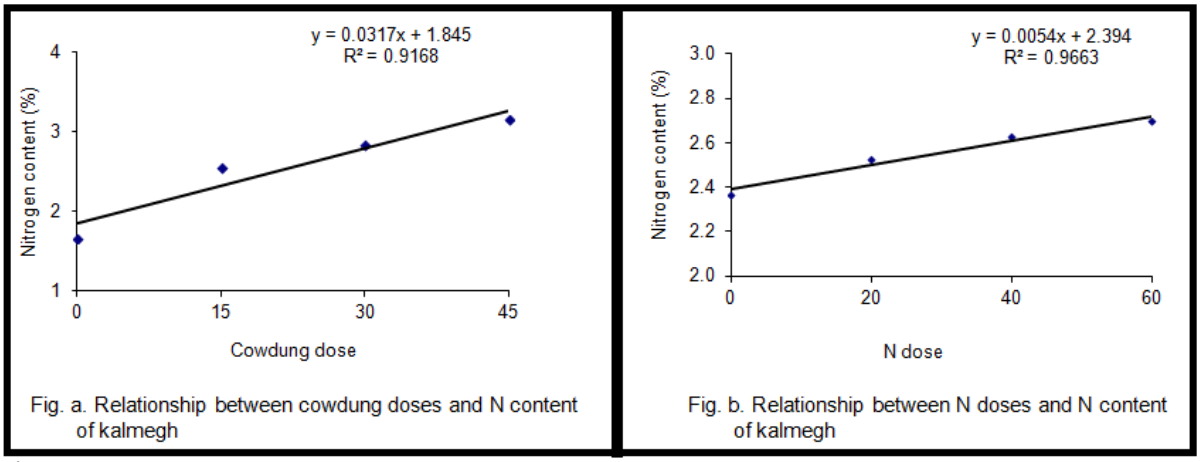

Fig. a. Relationship between cowdung doses and N content of kalmegh

Fig. b. Relationship between N doses and N content of kalmegh

Fig. 2. Relationships between cowdung and N doses and percent N content of kalmegh.

Root dry weight

Cowdung and N application was demonstrated negative impact on root dry weight of kalmegh per plant. The increasing rate of cowdung and N application had led to decrease the root dry weight. The highest root dry weight 4.24g and 3.15g per plant was observed from no cowdung and N applied treatment and the lowest root dry weight per plant was found from 45% cowdung (2.11g) and 60 kg N ha^{-1} (2.58g) applied treatment, respectively (Table 4). Similarly, the combined effect of different cowdung and N levels on the root dry weight of kalmegh was also significant (Table 5). The highest root dry weight (4.84g) was recorded from the treatment of C_0N_0 and the lowest value (2.03g) was observed from the highest combined application of $C_{45}N_{60}$.

Relationships between leaf, branch and root dry weight of kalmegh and the level of cowdung and nitrogen

Response of leaf dry weight of kalmegh to cowdung doses followed a linear relationship which could be adequately described by the regression equation as Y = 0.0824x + 21.876 (R^2 = 0.7699) and similarly, Y = 0.0773x + 21.411 (R^2 = 0.9899) to N doses (Fig. 1, a, b). The R^2 value indicated that 76% and 98% of the contribution to leaf dry weight of kalmegh could be explained by cowdung and N levels, respectively. These results indicated that with the increase of cowdung and N doses, leaf dry weight of kalmegh also increased.

Correspondingly, the linear relationship between branch dry weight and cowdung and N doses showed a regressionequation as Y= 0.3401x + 28.486 (R^2 = 0.8207) and Y= 0.1404x + 31.928 (R^2 = 0.9678) (Fig. 1, c, d). From the response curve (Fig. 1, c, d), it was found that branch dry weight was highly correlated with cowdung and N level and R^2 = 0.8207, 0.9663 indicated that maximum increase in branch dry weight by 82%, 96% was contributed by the highest cowdung (45%) and N (60 kg N /ha) level.

Root dry weight of kalmegh followed a linear relation which could be adequately described by the regression equation as Y = - 0.0473X + 3.901 (R^2 = 0.8465) to cowdung doses and Y = - 0.0098X + 3.133 (R^2 = 0.9738) to N doses (Fig. 1, e, f). The response curve showed that there was a weak negative relationship between root dry weight and cowdung and N levels. The relationship indicated that, the root dry weight of kalmegh was increased with the

decreasing rate of cowdung and N, because under the less nutrient supply condition, roots developed extensively to draw the nutrients from extended areas. In this process, total root dry weight was increased in less nutrient supply condition. It might be occurred, plants tend to accumulate more above ground biomass (shoot) when grown in nutrient rich soil, and accumulate more below ground biomass (root) when grown in nutrient poor soil. Because in this time roots uptake nutrients from extended areas. Therefore, total root biomass increase. As soil fertility increased further, root biomass decreases, but shoots weight continues to increase (Huxley, 1992).

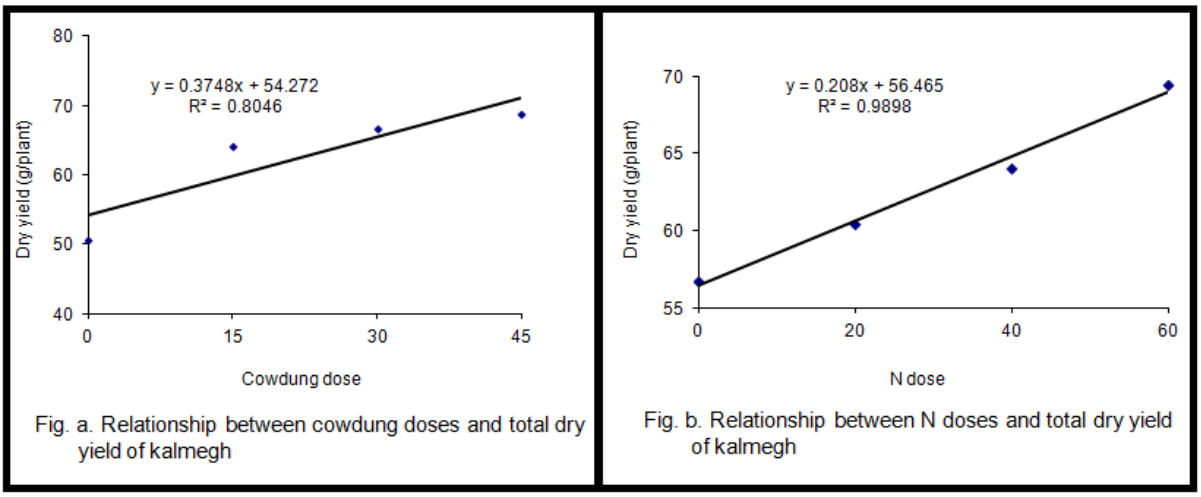

Fig. a. Relationship between cowdung doses and total dry yield of kalmegh

Fig. b. Relationship between N doses and total dry yield of kalmegh

Fig. 3. Relationships between cowdung and N dose and total plant dry yield of kalmegh.

Plant nitrogen content

The main effect of cowdung and N on the percent N content of kalmegh plant was significantly influenced (Table 6). In general, the highest N content (3.16%) was found from the treatment having 45% cowdung level and the lowest N content (1.67%) was observed from no N applied treatment. The highest N content (2.70%) was found from the 60 kg N ha^{-1} applied treatment, which was statistically identical with 40 kg N ha^{-1} applied treatment but different from rest of the N containing treatments. Oyinlola and Jinadu (2012)also reported that nitrogen content was increased with increasing rates of applied N in tomato leaves and fruits.

The integrated application of different cowdung and N levels showed the highest N content from the highest combined application of $C_{45}N_{60}$ (3.26%) which was closely identical with the combined application of $C_{45}N_{40}$ and $C_{45}N_{20}$ (Table 7). The lowest value (1.34%) was recorded from the control. On the other hand, Table 7 revealed that plant nitrogen content did not strongly varied with the increasing nitrogen levels but the highest N content of kalmegh plant was found when applied the higher amount of cowdung (45%).

Total plant fresh and dry yield

Total plant fresh and dry yield of kalmeghat maturity stage were significantly influenced by application of cowdung, and in each, the highest fresh (239.44 g) and dry (68.81g) yield were recorded under the highest level of cowdung application (45%) (Table 6). Similarly, total plant fresh and dry yield of kalmegh were also significantly increased by application of N and the highest value was recorded under the highest level of N application (60 kg N/ha). The interaction effect of cowdung and N on fresh and dry yield of kalomegh was also significant. The highest fresh yield (258.79g) wasrecordedfrom the highestcombined application of $C_{45}N_{60}$followed by $C_{45}N_{40}$ (Table 7). The present study showed that the fresh yield was increased with the increase of N and cowdung levels. The freshyield of the rest of the treatment combinations of C_0N_{60}, $C_{15}N_{40}$, $C_{15}N_{60}$, $C_{30}N_0$, $C_{30}N_{20}$, $C_{30}N_{40}$, $C_{30}N_{60}$, $C_{45}N_0$, $C_{45}N_{20}$did not vary statistically.

Similarly the highest dry yield per plant of kalmegh (74.8g) wasnoted from the highest combined application of $C_{45}N_{60}$,which was identical with the combined application of $C_{30}N_{60}$ (72.19g). Cheema *et al.* (2001) reported that increased nitrogen levels exhibits more dry matter production.

Relationship between percent N content of kalmegh and the level of cowdung and nitrogen

Linear relationship between percent N content of kalmegh plant and both cowdung and nitrogen levels was existed and estimated as $Y = 0.0317X + 1.845$ ($R^2 = 0.9168$) for cowdung level and $Y = 0.0054X + 2.394$ ($R^2 = 0.9663$) for N level (Fig. 2, a, b). The R^2 values in both the cases were high and significant. The relationship indicated that the variation in N content of kalmegh plant depends on different cowdung and nitrogen levels, and percent N content was increased under the highest cowdung (45%) and N (60 kg/ha) applied condition.

Relationships between dry yield of kalmegh and the level of cowdung and nitrogen

Response of total dry yield of kalmegh to cowdung and N doses produced a linear relation which could be adequately described by the regression equation as $Y = 0.3748x + 54.272$ ($R^2 = 0.8046$) (Fig. 3, a) and $Y = 0.208x + 56.465$ ($R^2 = 0.9898$) (Fig. 3, b), respectively. The response curve stated that total dry yield of kalmegh was highly correlated with cowdung and N level. In addition, $R^2 = 0.8046$ and $R^2 = 0.9898$ indicated that maximum increase in dry yield of kalmegh by 80% and 98% with the highest cowdung (45%) and N level (60 kg N ha^{-1}). Those linear relationships indicated that total dry yield of kalmegh increased with the increase of cowdung and nitrogen levels.

Conclusion

Results obtained from the study shows that the combined application of cowdung and N produce beneficial effect on growth and yield of important medicinal plant, kalmegh. It therefore, concluded that, a combination of 45% cowdung and 60 kg N/ha was considered to be the optimum level of cowdungand N for achieving the maximum growth and yield of kalmegh in the studied soil (Kodda soil) under Madhupur Tract. Since, the present study was conducted in one season only pot experiment, therefore further investigations are needed to be carried out with the best treatment combinations along with other micronutrients in the field environment for several seasons. The following are the landmarks of the present investigation that opening new possibilities for commercial cultivation of high drug yielding plants.

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