

# Growing Feasibility of Kalmegh Plant with Agar Plantation as Intercrop in Acid Soil

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**Abstract**—An experiment was conducted at Musagul village, Sujanagar union, Barlekhaupazila under Moulvibazar district during the period from September 2017 to October 2018 to know the performance of kalmegh plant with agar plantation as intercrop and to estimate the productivity of land due to intercropping. Three treatments were considered as Agar sole, Kalmegh sole and Agar + Kalmegh intercrop. The experiment was laid out in randomized complete block design with five replications. Data were taken on growth and biomass contributing characters of kalmegh plant viz. plant height, no. of leaves plant<sup>-1</sup>, no. of branches plant<sup>-1</sup>, leaf length, leaf breadth, spreading area, fresh biomass weight and dry biomass weight. Initial and post-harvest soil analyses were done for pH, organic matter, total N, available P, exchangeable K and available S. Plant analyses were also done for N, P and K concentrations of kalmegh plant (leaf, stem and root). Cost of production and return were estimated for medicinal and agar plants. The higher performance in plant growth parameters were found in kalmegh when intercropped with agar plantation in comparison to sole. Although there was no significant variations in agro-economic performance of medicinal plants between intercrop and sole plantation. The fresh biomass yield also gave higher in case of kalmegh intercrop (12700 kg ha<sup>-1</sup>) than sole (8153 kg ha<sup>-1</sup>) whereas the dry biomass was 4928 kg ha<sup>-1</sup> and 3235 kg ha<sup>-1</sup>, respectively for intercrop and sole. Nutrient uptake in the kalmegh plants followed the sequence of K (264.87 kg ha<sup>-1</sup>) > N (185.06 kg ha<sup>-1</sup>) > P (37.92 kg ha<sup>-1</sup>). Nutrient concentrations were increased in post-harvest soils in comparison to initial soil due to application of fertilizers. The productivity of land was increased in intercrop association over sole plantation.

## 1. Introduction

Kalmegh (*Andrographispaniculata*) is a well-known medicinal plant under the family of Acanthaceae. It is also known as king of bitter (Mishra, 2009). It commonly grows in Southeast Asian countries such as Sri Lanka, Pakistan, Malaysia and Indonesia and has been cultivated extensively for medicinal purpose in India, China, Thailand, East and West Indies and Mauritius (Kataky, 2010; Niranjana, 2010). This plant is best suited in hot and humid climate in subtropical regions (Niranjana, 2010). In Bangladesh it is used as medicinal plant from time immemorial. *Andrographispaniculata* is widely used for medicinal and pharmacological purpose. It is used in

different systems of medicine and exhibit anti-malarial, antidiabetic, antipyretic, hepatoprotective, anti-inflammatory and anticancer etc. The demands of medicinal plants is increasing day by day, it is generally felt to expand its cultivation areas to ensure regular availability to the industry as well as to people associated with traditional system of medicines (Panwar, 2017). Agar tree (*Aquilariamelaccensis*) is a slow growing plant and it produced resinous wood that is called agarwood (Blanchette, 2006). It requires 15-16 years generally to get profit from agar. In the mean-time if farmer can intercrop medicinal plants they will get extra income from that land. Agar tree contains spreading canopy it allows partial penetration of sunlight. Shade loving medicinal plants like kalmegh (*Andrographispaniculata*) may be grown for another few years depending on plant population and land type. The study was aimed to observe the performance of kalmegh plant as intercrop and increase the productivity of land in agar plantation.

## 2. Materials and Methods

An experiment was conducted at Musagul village, Sujanagar union, Barlekhaupazila under Moulvibazar district during the period from September 2017 to October 2018. The experimental site belongs to Northern and Eastern Hills (Agro-Ecological Zone-29) and acidic soil. The soil having pH 4.3, total N 0.12 %, OM 2.16 %, exchangeable K 0.11 meq/100 g soil, available P 55 ppm and available S 10 ppm. Kalmegh (*Andrographispaniculata*) was intercropped with Agar plant. Three treatments were considered as Agar Sole, Kalmegh Sole and Agar + Kalmegh intercrop. The experiment was laid out in randomized complete block design with five replications. Each replication was divided into three plots. The size of unit plot was 3 m × 2 m e.i. 6 m<sup>2</sup>. The total number of unit plot was 15. Block to block distance 1 m and plot to plot distance 0.5 m was maintained. Initial soil sample of the experimental plots were collected from 0-15 cm soil depth. The field preparation for plantation was done at 28 September to 30 September 2017 and the kalmegh was planted on 1-2 October 2017. The TSP and MoP were applied during

final land preparation on the basis of farmers practice and nitrogen fertilizer was applied in four equal splits as after 20 days after planting, 3 months after planting, 6 months after planting and finally 9 months after planting. The experimental field was frequently monitored and necessary management practices such as irrigation, weeding were done as per required. Data were taken on growth and biomass contributing characters of kalmegh plant viz. plant height (cm), no. of leaves plant<sup>-1</sup>, no. of branches plant<sup>-1</sup>, leaf length (cm), leaf breadth (cm), spreading area (cm<sup>2</sup>), fresh biomass weight (g) and dry biomass weight (g). Growth parameters were recorded at 15 days interval after planting up to started from 15 to 225 days. Initial and post-harvest soil analyses were done for pH, organic matter, total N, available P, exchangeable K and available S. Plant analyses were also done for N, P and K concentrations of kalmegh plant. Cost of production was estimated for medicinal and agar plants. Statistical analyses were done through R (package) software.

### 3. Results and discussions

#### 3.1 Effect of intercropping on Growth parameters of medicinal plants

The growth parameters of kalmegh did not vary significantly at different days of intervals up to 225 days after planting for intercropping with agar plants. Most of the cases in intercrop growth parameters performed better than sole of kalmegh. The plant heights of kalmegh recorded 53.33 cm for sole and as an intercrop it was recorded 59.95 cm at 225 days after planting (Table 1). Number of leaves plant<sup>-1</sup> of kalmegh were recorded 66.28 and 68.06 at 225 days after planting for sole and intercrop, respectively (Table 2). In case of leaf length it showed significant relations at 30, 45, 60 and 75 days after planting for intercropping with agar plants (Table 3). At 225 days after planting leaf length recorded higher in intercrop (13.80 cm) than sole (13.56 cm). For leaf breadth at 45 and 75 days after intervals leaf breadth of kalmegh showed significant differences at 5% level of significance (Table 4). At 225 days after planting it recorded 3.34 cm and 3.04 for sole and intercrop, respectively. Spreading areas were recorded 26.47 and 29.25 cm<sup>2</sup> for sole and intercrop, respectively (Table 5). Number of branches plant<sup>-1</sup> of kalmegh was recorded 9.30 and 10.32 for sole and intercrop, respectively (Table 6). The results are in agreement with Ramesh and Shivana (2010). They grow kalmegh at Kannamangla Horticulture Farm, near Bangalore to study the performance as an intercrop in coconut plantations of different age group. Kalmegh performed better as an intercrop in 25 years old coconut garden. The yield parameters such as fresh weight of leaves, fresh weight plant<sup>-1</sup>, fresh weight plot<sup>-1</sup>, dry weight plot<sup>-1</sup> and herb yield also recorded higher when *Andrographis paniculata* was intercropped in more than 25-year-old coconut garden as compared to control.

**Table 1: Effect of intercropping on plant height of kalmegh with agar plantation at different days of intervals**

| Days of intervals | Plant height (cm) |           | Standard error | Level of significance |
|-------------------|-------------------|-----------|----------------|-----------------------|
|                   | Sole crop         | Intercrop |                |                       |
| 15                | 19.12             | 16.16     | 0.91           | NS                    |
| 30                | 20.19             | 17.92     | 1.02           | NS                    |
| 45                | 21.29             | 21.18     | 0.95           | NS                    |
| 60                | 21.99             | 21.98     | 0.95           | NS                    |
| 75                | 23.35             | 22.58     | 0.48           | NS                    |
| 90                | 24.33             | 23.68     | 0.74           | NS                    |
| 105               | 25.22             | 25.50     | 0.80           | NS                    |
| 120               | 26.10             | 26.47     | 0.89           | NS                    |
| 135               | 27.76             | 29.22     | 1.58           | NS                    |
| 150               | 29.66             | 30.27     | 1.89           | NS                    |
| 165               | 33.30             | 34.06     | 1.97           | NS                    |
| 180               | 38.70             | 40.30     | 2.72           | NS                    |
| 195               | 45.77             | 47.33     | 2.10           | NS                    |
| 210               | 46.73             | 54.89     | 4.53           | NS                    |
| 225               | 53.33             | 59.95     | 4.70           | NS                    |

NS= Not significant

**Table 2: Effect of intercropping on number of leaves plant<sup>-1</sup> of kalmegh with agar plantation at different days of intervals**

| Days of intervals | Number of leaves plant <sup>-1</sup> |           | Standard error | Level of significance |
|-------------------|--------------------------------------|-----------|----------------|-----------------------|
|                   | Sole crop                            | Intercrop |                |                       |
| 15                | 8.40                                 | 9.80      | 0.57           | NS                    |
| 30                | 10.72                                | 12.36     | 0.68           | NS                    |
| 45                | 12.34                                | 12.78     | 1.45           | NS                    |
| 60                | 11.64                                | 12.24     | 1.10           | NS                    |
| 75                | 12.46                                | 11.24     | 1.66           | NS                    |
| 90                | 14.48                                | 13.97     | 1.54           | NS                    |
| 105               | 16.71                                | 15.82     | 1.14           | NS                    |
| 120               | 17.92                                | 19.15     | 1.71           | NS                    |
| 135               | 18.92                                | 20.36     | 1.73           | NS                    |
| 150               | 20.77                                | 22.37     | 1.86           | NS                    |
| 165               | 30.68                                | 30.40     | 2.78           | NS                    |
| 180               | 39.14                                | 37.54     | 4.70           | NS                    |
| 195               | 46.42                                | 46.72     | 4.42           | NS                    |
| 210               | 54.78                                | 56.70     | 4.96           | NS                    |
| 225               | 66.28                                | 68.06     | 5.69           | NS                    |

NS= Not significant

**Table 3: Effect of intercropping on leaf length of kalmegh with agar plantation at different days of intervals**

| Days of intervals | Leaf length (cm) |           | Standard error | Level of significance (LSD value) |
|-------------------|------------------|-----------|----------------|-----------------------------------|
|                   | Sole crop        | Intercrop |                |                                   |
| 15                | 11.16            | 8.78      | 0.64           | NS                                |
| 30                | 11.24a           | 9.28b     | 0.43           | *(1.72)                           |
| 45                | 13.32a           | 9.54b     | 0.83           | *(3.29)                           |
| 60                | 13.50a           | 10.52b    | 0.57           | *(2.24)                           |
| 75                | 12.65a           | 10.00b    | 0.59           | *(2.32)                           |
| 90                | 11.27            | 10.27     | 0.97           | NS                                |
| 105               | 12.50            | 10.20     | 0.97           | NS                                |
| 120               | 12.44            | 11.09     | 1.17           | NS                                |

|      |       |       |      |    |
|------|-------|-------|------|----|
| 135  | 12.64 | 10.22 | 1.15 | NS |
| 150  | 12.89 | 10.41 | 1.16 | NS |
| 165  | 11.64 | 11.26 | 0.96 | NS |
| 180  | 12.64 | 12.26 | 0.81 | NS |
| 195  | 12.77 | 13.13 | 1.00 | NS |
| 210  | 12.90 | 13.34 | 0.73 | NS |
| 225  | 13.56 | 13.80 | 0.72 | NS |
| Mean | 13.80 | 10.94 | -    |    |

In a row, the figure(s) having dissimilar letter(s) differ significantly \* = Significant at 5 % level of probability, NS= Not significant, LSD= Least significance difference

**Table 4: Effect of intercropping on leaf breadth (cm) of kalmegh with agar plantation at different days of intervals**

| Days of intervals | Leaf breadth (cm) |           | Standard error | Level of significance (LSD value) |
|-------------------|-------------------|-----------|----------------|-----------------------------------|
|                   | Sole crop         | Intercrop |                |                                   |
| 15                | 2.26              | 1.64      | 0.19           | NS                                |
| 30                | 2.58              | 2.22      | 0.24           | NS                                |
| 45                | 2.72a             | 1.90b     | 0.17           | * (0.68)                          |
| 60                | 2.72              | 2.42      | 0.15           | NS                                |
| 75                | 2.68a             | 2.22b     | 0.10           | * (0.40)                          |
| 90                | 2.51              | 2.05      | 0.14           | NS                                |
| 105               | 2.49              | 1.87      | 0.18           | NS                                |
| 120               | 2.60              | 2.34      | 0.17           | NS                                |
| 135               | 2.73              | 2.58      | 0.21           | NS                                |
| 150               | 2.86              | 2.64      | 0.17           | NS                                |
| 165               | 2.62              | 2.66      | 0.06           | NS                                |
| 180               | 2.73              | 2.74      | 0.09           | NS                                |
| 195               | 2.98              | 2.76      | 0.21           | NS                                |
| 210               | 3.20              | 2.90      | 0.21           | NS                                |
| 225               | 3.34              | 3.04      | 0.24           | NS                                |
| Mean              | 2.55              | 3.04      | -              |                                   |

In a row, the figure(s) having dissimilar letter(s) differ significantly \* = Significant at 5 % level of probability, NS= Not significant, LSD= Least significance difference

**Table 5: Effect of intercropping on spreading area of kalmegh sole and intercrop with agar plantation at different days of intervals**

| Days of intervals | Spreading area (cm <sup>2</sup> ) |           | Standard error | Level of significance |
|-------------------|-----------------------------------|-----------|----------------|-----------------------|
|                   | Sole crop                         | Intercrop |                |                       |
| 15                | 13.10                             | 11.36     | 0.60           | NS                    |
| 30                | 14.80                             | 13.48     | 0.83           | NS                    |
| 45                | 16.46                             | 14.24     | 1.14           | NS                    |
| 60                | 15.52                             | 14.54     | 0.88           | NS                    |
| 75                | 16.20                             | 17.34     | 0.83           | NS                    |
| 90                | 16.76                             | 17.12     | 0.63           | NS                    |
| 105               | 17.16                             | 19.16     | 1.99           | NS                    |
| 120               | 18.93                             | 22.23     | 1.76           | NS                    |
| 135               | 18.55                             | 21.35     | 0.60           | NS                    |
| 150               | 19.34                             | 21.92     | 1.89           | NS                    |
| 165               | 20.88                             | 23.88     | 2.16           | NS                    |
| 180               | 22.23                             | 25.44     | 2.06           | NS                    |
| 195               | 23.59                             | 26.86     | 2.27           | NS                    |
| 210               | 25.06                             | 28.47     | 2.05           | NS                    |
| 225               | 26.47                             | 29.25     | 2.15           | NS                    |

NS= Not significant

**Table 6: Effect of intercropping on number of branches plant<sup>-1</sup> of kalmegh with agar plantation at different days of intervals**

| Days of intervals | Number of branches plant <sup>-1</sup> |           | Standard error | Level of significance |
|-------------------|--|-----------|----------------|-----------------------|
|                   | Sole crop                              | Intercrop |                |                       |
| 15                | 0.80                                   | 0.00      | 0.41           | NS                    |
| 30                | 1.60                                   | 1.20      | 0.52           | NS                    |
| 45                | 1.72                                   | 1.20      | 0.36           | NS                    |
| 60                | 1.80                                   | 1.60      | 0.56           | NS                    |
| 75                | 1.36                                   | 0.98      | 0.61           | NS                    |
| 90                | 1.66                                   | 1.76      | 0.76           | NS                    |
| 105               | 2.84                                   | 2.59      | 0.48           | NS                    |
| 120               | 3.22                                   | 3.93      | 0.73           | NS                    |
| 135               | 3.53                                   | 4.46      | 0.87           | NS                    |
| 150               | 4.02                                   | 4.86      | 0.94           | NS                    |
| 165               | 4.92                                   | 6.22      | 0.93           | NS                    |
| 180               | 5.92                                   | 7.44      | 0.93           | NS                    |
| 195               | 6.80                                   | 8.54      | 0.90           | NS                    |
| 210               | 7.80                                   | 9.60      | 0.86           | NS                    |
| 225               | 9.30                                   | 10.32     | 1.28           | NS                    |

NS= Not significant

### 3.2 Effect of intercropping on biomass characters of kalmegh

The biomass production of kalmegh did not vary significantly for intercropping with agar plants. The higher fresh weight of leaves was found in intercrop with agar plantation (6040 kg ha<sup>-1</sup>) then in sole crop (3080 kg ha<sup>-1</sup>). The higher fresh weight of stem was produced by intercrop (4430 kg ha<sup>-1</sup>) than sole crop (3239 kg ha<sup>-1</sup>). Fresh weight of root was produced higher in intercrop (2230 kg ha<sup>-1</sup>) as compare to sole crop (1834 kg ha<sup>-1</sup>). In case if total fresh biomass, the higher yield was obtained in intercrop (12700 kg ha<sup>-1</sup>) then in sole crop (8153 kg ha<sup>-1</sup>). Similarly, higher dry biomass for leaf, stem, root and total production was recorded in intercrop than sole crop (Table 7). Mishra et al (2007) reviewed that kalmegh is an annual, branched, herbaceous plant in Indian condition, the yield varies between 2000-2500 kg dry herbs per hectare.

**Table 7: Biomass production of kalmegh under intercropping system with agar plantation**

| Biomass | Fresh weight(kg ha <sup>-1</sup> ) |               | Dry weight(kg ha <sup>-1</sup> ) |              |
|---------|------------------------------------|---------------|----------------------------------|--------------|
|         | Sole                               | Intercrop     | Sole                             | Intercrop    |
| Leaf    | 3080 (±1306)                       | 6040 (±2113)  | 1028 (±278)                      | 2106 (±826)  |
| Stem    | 3239 (±2998)                       | 4430 (±1433)  | 1246 (±1255)                     | 1461 (±974)  |
| Root    | 1834 (±1537)                       | 2230 (±722)   | 960 (±1022)                      | 1360 (±467)  |
| Total   | 8153 (±5678)                       | 12700 (±4152) | 3235(±2411)                      | 4928 (±2160) |

Std= Standard deviation

### 3.3 Nutrient uptake by kalmegh plant parts

The nitrogen uptake in leaf, stem and root of kalmegh plant were 65.83, 42.08 and 77.15 kg ha<sup>-1</sup>, respectively (Table 8). Among them, uptake by the root was the highest (77.15 kg ha<sup>-1</sup>).

<sup>1</sup>). The phosphorous uptake in leaf, stem and root were 15.70, 15.06 and 7.16 kg ha<sup>-1</sup>, respectively. The highest uptake of phosphorus by the leaves was recorded (15.70 kg ha<sup>-1</sup>). Again, the potassium uptake in leaf, stem and root were 128.65, 97.46 and 38.57 kg ha<sup>-1</sup>, respectively. Like phosphorus, the highest uptake of potassium (128.65 kg ha<sup>-1</sup>) by the leaves was found. Potassium uptake is the highest by kalmegh as comparison to nitrogen and phosphorous (Table 8). According to Sanjutha et al. (2008) in kalmegh plant after harvest the maximum nutrient content 2.88, 0.32 and 3.12 percent N, P and K respectively, and the nutrients uptaken by kalmegh leaf were 80.47, 8.94 and 87.18 Kg ha<sup>-1</sup> of N, P and K respectively.

**Table 8: Amount of N, P and K uptake from soil by kalmegh plant under intercropping system with agar plantation**

| Plant parts | Nutrient Uptake       |                       |                       |
|-------------|-----------------------|-----------------------|-----------------------|
|             | N kg ha <sup>-1</sup> | P kg ha <sup>-1</sup> | K kg ha <sup>-1</sup> |
| Leaf        | 65.83                 | 15.70                 | 128.65                |
| Stem        | 42.08                 | 15.06                 | 97.46                 |
| Root        | 77.15                 | 7.16                  | 38.57                 |
| Total       | 185.06                | 37.92                 | 264.87                |

### 3.4 Cost of production

The costs of production of agar plant for fifteen year were estimated as Tk. 632920ha<sup>-1</sup>. The total returns of fifteen year were Tk. 6282954. From estimation gross margin was revealed Tk. 5650034. For one year the cost of production of kalmegh plant estimated Tk. 81804ha<sup>-1</sup>. Total return was Tk 295680 ha<sup>-1</sup> year<sup>-1</sup>. The gross margin from a year was Tk 213876. The costs of production of medicinal plants were estimated for one year. The harvesting of agar plant is to be started from 15 years old. In agar garden, medicinal plants can be intercropped for around 8-10 years. Due to experimental purpose it was not possible to extend more than one year intercropping in agar garden. But to know the actual profitability, it needs total estimation of biomass for fifteen years. In one year, the gross margin of kalmegh plant estimated Tk. 213876 (Table 9). Intercropping increases the additional source of income is supported by Nair et al. (1991). Nair et al. (1991) observed intercropping of 13 medicinal/aromatic plants in a 12 year-old coconut plantation. The growth and yield of the plants did not affected when grown as intercrops in coconut plantation in comparison to the open condition. Growing medicinal plants in the interspaces of coconut plantations become an additional source of income to the farmers.

**Table 9: Agro-economic performance of agar plant with medicinal plants**

| Sl. No | Plants         | Cost of production Tk ha <sup>-1</sup> | Gross return Tk ha <sup>-1</sup> | Gross margin Tk ha <sup>-1</sup> |
|--------|----------------|--|----------------------------------|----------------------------------|
| 01     | Agar *         | 632920                                 | 6282954                          | 5650034                          |
| 02     | Kalmegh**      | 81804                                  | 295680                           | 213876                           |
| 07     | Agar + Kalmegh | 714724                                 | 6578634                          | 7361042                          |

\*Calculation of cost and return for 15 year

\*\* Calculation of cost and return for 1 year

### Conclusion

Medicinal plants were highly demanding crop now-a-days. Kalmegh showed feasibility in agar plantation. So, it can be conclude that kalmegh would be practicable in agar plantation and it could increase the productivity of land.

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