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EFFECT OF CROPPING SYSTEM AND FERTILIZERS ON CLUMP FORMATION IN *CYMBOPOGON FLEXUOSUS* UNDER *DALBERGIA SISSOO* ROXB. BASED AGROFORESTRY SYSTEM IN *ENTISOLS*

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ABSTRACT

The experiment was carried out at the Dr. Richharia Research and Instructional Farm, Baronda Department of Forestry, IGKV, Raipur, Chhattisgarh under 10 years old plantation of *Dalbergia sissoo* Roxb. based agroforesty system in *Entisols* for two years of cropping seasons *i.e.* 2007-08 & 2008-09. Wasteland development and ecofriendly agriculture has its priority for safe products, so the objective of this study was to investigate the effect of cropping system and fertilizer on clump formation in *Cymbopogon flexuosus* under *Dalbergia sissoo* Roxb based agroforestry system. The plantation of *D. sissoo* at the spacing of 5 x 5 m was established in the year 1998; however under storey crop of *C. flexuosus* was introduced in July 2007 as an intercrop in interspace and in rainfed condition as sole crop on Bhata soil with application of 30 kg N, 20 kg P & K comprising eight different treatments [T_1- $N_0P_0K_0$, T_2- $N_{30}P_0K_0$, T_3- $N_0P_{20}K_0$, T_4- $N_0P_0K_{20}$, T_5- $N_{30}P_{20}K_0$, T_6- $N_{30}P_0K_{20}$, T_7- $N_0P_{20}K_{20}$ and T_8- $N_{30}P_{20}K_{20}$] etc using a split plot design. The results showed that the highest number of tillers per plant was (99.02), highest number of leaves per tiller was (12.45), maximum clump diameter was (16.35 cm) and maximum (211.19 cm^2) basal area of clump was observed for Lemongrass in sole cropping system as compared to agroforestry at all three cut in both the cropping years. Production of Lemon grass was taken by three cut in September, December and February in a year. Application of NPK gave positive results of growth performance. However the different combination of NPK (30 kg N, 20 kg P & K) showed the application of N+K was more effective as compare to N+P and P+K. Effect of fertilizers on growth of *C. flexuosus* were observed in order of T8 > T6 > T5 > T7 > T2 > T4 > T3 > T1 in all the three harvesting during both the cropping years with statistically significant variations. The treatment T_{8-} [$N_{30}P_{20}K_{20}$] showed the best results in Lemongrass growth performance under agroforestry as well as in sole cropping system in respect to number of tillers per clump, the number of leaves per tiller, clump diameter and basal area of clump etc. From these results, it could be recommended that T_8- [$N_{30}P_{20}K_{20}$] was the best treatment for Lemongrass growth under agroforestry.

***Keywords*:** Cropping system, Agroforestry, Clump, Tiller, Basal area, Red Lateritic soil, *Entisols,* Bhata soil, Wasteland, Aromatic plants, *Cymbopogon flexuosus* & *Dalbergia sissoo* etc.

INTRODUCTION

Agroforestry plays a vital role in the Indian economy by way of tangible and intangible benefits. In fact, agroforestry has high potential for simultaneously satisfying three important objectives viz., protecting and stabilizing the ecosystems; producing a high level of output of economic goods; and improving income and basic materials to rural population. It has helped in rehabilitation of degraded lands on one hand and has increased farm productivity on the other (Dhyani, 2018). In the recent past, there is greater demand for medicinal and aromatic plants as they are the raw material for pharmaceutical, perfumery, cosmetics and confectionery industries. Therefore, the present investigation was under taken with Lemongrass as under storey crop with *Dalbergia sissoo* based agroforestry cropping system. Soil fertility decline happens as a result of exploiting the soil by the production of plants without restoring the consumed nutrients, so soil fertility needs to be maintained by using NPK fertilizers and existing tree of *Dalbergia sissoo* in agroforestry that cause nutrient exchanges between fertilizers, soil, and water (El-Sayed, *et al.,* 2018). Wasteland development and eco-friendly agriculture has priority for safe products, so this work concerns with improving the quality of soil and productivity of lemongrass by using agroforestry farming system with supplementary addition of NPK fertilizers.

Lemongrass is an important aromatic cum medicinal herb. It belongs to the Poaceae family, plants are extensively adapted to various agro-climatic zones in India and mostly grow wild as natural vegetation, and fluctuations of weather conditions mainly influence their performance. Lemongrass flourishes in a wide variety of soil ranging from rich loam to poor laterite. It is extensively cultivated in poor, marginal and wastelands and also along the bunds as live mulch. The well ramified root system of the plants helps in soil and water conservation (Gawali and Meshram, 2019). The plant is hardy and resistant to draught along with maximum plant height during rainy season. Essential oil of Lemongrass is used in the flavouring of food, in cosmetic as well as in pharmaceutical industries Singh *et al.* (2000). The most economical way to extract the essential oil is to transport the harvested biomass directly to the distillery. The essential oil contains 70-90% Citral, which is a mixture of the two isomers geranial and neral, the ratio between them usually being in the 40:60 to 60:40 ranges Baser and Buchbauer, (2015). Lemongrass has excellent antioxidant properties and has been reported to have sedative, spasmolytic, carminative, antibacterial, antimutagenic, antimalarial, antifungal, larvicidal, antinociceptive, anti- inflammatory, and antioxidant properties Charles, (2012). Dried lemongrass leaves are widely used as a lemon flavour ingredient in herbal teas, prepared either by decoction or infusion of 2-3 leaves in 250 or 500 ml of water and other formulations (Gawali and Meshram, 2019).

Dalbergia sissoo Roxb. is one of the tropical timber tree species with multiple uses such as fuelwood, fodder, pulp, shade, shelter and N-fixing ability (Sharma *et al*., 2007). It is widely used in agroforestry, afforestation programmes and farm forestry in the Indian subcontinent (Huda *et al*., 2007). Furthermore, it was observed that freely available eco-friendly organic fertilizers in conjunction with inorganic fertilizers have immense potential of supplementing a part of nitrogen and other nutrients through efficient mineralization to the associated crop in tree based cropping systems (Subba Reddy *et al*., 1991). The basic aim of planting tree species is to rehabilitate highly eroded areas, check soil and water losses and improves the degraded lands to provide fuel wood, fodder and timber to the poor famers (Singh *et al.*, 2009). The wider use of MPTS, in agroforestry system especially nitrogen fixing tree species, would become an important factor in improving productivity and maintaining an enhanced nitrogen status in many tropical land use systems and also increase productivity and economic returns. Therefore, multipurpose tree species should be introduced in degraded lands to exploit their ability to provide the basic needs of people and protect the environment which also play main role for soil conservation and management (Mutanal *et al.,* 2016). Hence, looking to the importance of *Cymbopogon flexuosus* and *Dalbergia sissoo* as important crops, the present investigation was carried out in agroforestry system in red lateritic soil in Chhattisgarh.

MATERIALS AND METHODS

The present experiment was conducted in 10 years old plantation of *Dalbergia sissoo* Roxb. based agroforesty system in *Entisols* for two years of cropping seasons *i.e.* 2007-08 & 2008-09 at Dr. Richharia Research and Instructional Farm, Baronda Department of Forestry, IGKV, Raipur (CG). The study site falls under the central region of Chhattisgarh plains agro-climatic zone with 21.37 ^{o} N and 81.82^{o} E. The plantation of *Dalbergia sissoo* at the spacing of 5 x 5 m was established in the year 1998; however under storey crop of *Cymbopogon flexuosus* was introduced in July 2007 as an intercrop in interspace. The climate of study site is dry humid sub-tropical with an average annual rainfall of 1250 mm. About 80 percent of the annual rainfall is received from south- west monsoon during June to mid August. Number of rainy days varies from 65 to 79 days. The mean monthly maximum temperature varies from 13.2^{0}C in December to 28.3^{0}C in May with maximum temperature goes beyond 45^{0}C in May and minimum below 10^{0}C in December. The relative humidity lies between 70-90 per cent from mid June to March end. Physico-chemical features of the *Entisols* locally known as Bhata land, it is also known as red lateritic soil, as land use classification pattern point of view, and it comes under marginal wasteland. These lands have long gentle slopes with undulating topography (Pofali and Bhattacharjee, 1970). The soil having high percentages of gravels and sub soil layers are hard and compact, forming even lateritic pans at places (Singh and Totey, 1985). In red lateritic soil, the content of organic matter are found in fewer amounts, which is responsible for causing moisture and thermal stress, which affect microbial activity and the availability of nutrients and subsequently affect the growth of plant (Gupta and Sharma 2009). Low pH (acidic highly), low nitrogen, high potassium and low phosphorus with low organic matter are the basic characteristics of *Entisols.*

Preparation of land, Manure and fertilizers: The experimental field was thoroughly prepared by ploughing and repeated harrowing with the help of cultivator and disc harrow before transplanting the lemongrass. FYM was applied @ 10 t/ha to all the plots uniformity and was well mixed in to the soil at the time of land preparation. Fertilizers was applied in two split doses during planting *i.e.* July/Aug and followed by 45 days after planting (second dose). N-Nitrogen in form of Urea, P-Phosphorus in form of Single super phosphate and K- Potash at the rate of 30 kg N/ha, 20 kg P/ha, and 20 kg K/ha.

Sowing of *Cymbopogon flexuosus* and their Management: The rooted slips of *Cymbopogon flexuosus* was transplanted at a distance of one meter spacing in both as intercrops as well as pure crops, gap filling was done with the same aged rooted slips to maintain plant population of each plots of experiment. A light irrigation was given immediately after transplanting for better establishment of the rooted slips in the field. The subsequent irrigation was given at an interval of ten days when as required. Weeding and hoeing were done at 20 days interval to keep the plots clean and free from weeds. Plant populations did not require any necessary insect-paste management as no serious pests and diseases were observed on the grass during the experiment. However other cultural practices were followed as per recommendations (Farooqi, 2004).

Crop observations: To study growth behavior of *C. flexuosus* following plant characteristics was observed as sole crop (*i.e.* without tree) and as intercrop with tree of *D. sissoo* under different fertilizer treatments. Thus 16 treatments were observed at fifteen days interval. Group of ten plants (Clumps) were randomly selected for observation during study of two cropping season. The number of tillers per clump was counted, the numbers of leaf per tiller in the clump was also counted for calculating average number of leaf per tiller and the diameter of clump was measured with the help of digital caliper. We also observed basal area of clump in each plot of different treatments sample during the study.

RESULTS AND DISCUSSION

Lemon grass, grown as component of agroforestry system and as sole crop in open area with application of fertilizers for two years, to study its clump formation & growth, the data are presented here sequentially for number of tiller per plant, number of leaves per tiller, diameter of clump and basal area of clump for both the cropping year *i.e.,* 2007-08 and 2008-09.

1. Number of Tillers per plant of *Cymbopogon flexuosus*

In gramineae family tillers formation in clump is important phenomena because each tillers is accounted as single plant unit in whole plant or clump. Thus higher number of tillers means higher potential of biomass and reproductive. The effect of cropping system, fertilizers and their interaction on *C. flexuosus* are presented here with table and figures.

Effect of cropping system: Effect of cropping system on number of tillers per plant of *C. flexuosus* after planting is presented in figure1.1. During first year the population of tillers was 71.47 and 64.44 tillers plant^{-1} whereas, second year cropping season it was noted 99.02 and 84.63 tillers plant^{-1} for sole crop and in intercrop under agroforestry system respectively after 75 days of planting (DAP), while after 90 days of first harvesting, the number of tillers per plant was available 65.50 and 51.63 tillers plant^{-1} in first year cropping season whereas, second year cropping season it was noted 78.47 and 72.39 tillers plant^{-1} for sole crop and in intercrop under agroforestry system respectively during second harvesting. After 75 days of second harvesting these tillers were 34.85 and 28.40 tiller plant^{-1} in first year cropping season, while second year it was noted 72.59 and 63.53 tillers plant^{-1} for sole crop and in intercrop for third harvest respectively. Number of tillers per plant was higher under sole crop as compared to intercrop under agroforestry system in all the three growing phase and harvesting in both the cropping year with statistically significant results ($P<0.05$ %). The number of tillers per plant was higher in crop during first harvesting and it decrease sequentially during second and third harvesting.

***Effect of Fertilizer* :** Effect of fertilizer on number of tillers per plant of *C. flexuosus* during first year showed that ranged between 46.62 to 88.43 tillers plant^{-1} while second year it ranged between 78.98 to 100.97 tillers plant^{-1} up to first harvesting (75 DAP). In the first year cropping the maximum number of tillers per plant was found in treatment T_8 (88.43 tillers plant^{-1}) followed by T_6 (68.46 tillers plant^{-1}), T_5 (66.11 tillers plant^{-1}), T_7 (64.14 tillers plant^{-1}) and minimum was found in treatment T_1 (46.62 tillers plant^{-1}) with statistically significant variations ($P<0.05$ %). Whereas after 90 days of first harvesting, it was ranged between 38.35 to 72.96 tillers plant^{-1} and the maximum number of tillers per plant was found in treatment T_8 (72.96 tillers plant^{-1}) followed by T_6 (69.87 tillers plant^{-1}), T_5 (67.51 tillers plant^{-1}), T_7 (59.56 tillers plant^{-1}) and T_2 (55.34 tillers plant^{-1}) with minimum T_1 - (38.35 tillers plant^{-1}). In case of third growth phase, it was ranged between 28.32 to 38.24 tillers plant^{-1} at 75 DASH, where maximum was found in treatment T_8 (38.24 tillers plant^{-1}) followed by T_6 (34.93 tillers plant^{-1}), T_5 (32.19 tillers plant^{-1}), T_7 (31.05 tillers plant^{-1}) and T_2 (29.85 tillers plant^{-1}) with minimum in T_1 (28.32 tillers plant^{-1}). The effect of fertilizer treatment on population of tillers growth followed same pattern in second year also. Overall the results were found statistically significant ($P<0.05$ %). The population of tillers followed the decreasing pattern in order of first, second and third harvesting in both the cropping year (Fig 2.1).

2. Number of Leaves per tiller of *Cymbopogon flexuosus*

Number of leaves per tillers as well as plant is important growth parameter in crop because it is subjected to essential oil production in terms of oil content in leaves. Thus more number of leaves means production of more essential oil. The effect of cropping system, fertilizers and their interaction on number of leaves per tillers of *C. flexuosus* are presented here with table and figures.

***Effect of cropping system*:** Effect of cropping system on number of leaves per tiller of *C. flexuosus* after planting is presented in figure 1.2. During first year the number of leaves per tiller was 11.84 and 09.66 leaves tiller^{-1} whereas second year it was noted 12.45 and 11.18 leaves tiller $^{-1}$ for sole crop and in intercrop under agroforestry system respectively after 75 days of planting (DAP), while after 90 days of first harvesting, the number of leaves per tiller was available 10.28 and 9.55 leaves tiller^{-1} in first year whereas second year of cropping it was noted 10.84 and 10.37 leaves tiller^{-1} respectively for second harvesting. After 75 days of second harvesting these leaves number were 9.05 and 7.26 leaves tiller^{-1} in first year while second year it was noted 9.38 and 9.08 leaves tiller^{-1} for sole crop and intercrop respectively for third harvest. Number of leaves per tiller of *C. flexuosus* were higher under sole crop during all the three growing phase and harvesting in both the cropping year with statistically significant ($P<0.05$ %). The numbers of leaves were found higher in crop during first harvesting and it decrease sequentially during second and third harvesting.

***Effect of Fertilizer*:** Effect of fertilizer on number of leaves per tiller of *C. flexuosus* during first year showed that ranged between 9.08 to 12.59 leaves tiller^{-1} while in second year it ranged between10.18 to 14.05 leaves tiller^{-1} up to first harvesting (75 DAP) with statistically significant differences. In the first year of cropping the maximum number of leaves were found in treatment T_8 (12.59 leaves tiller^{-1}) followed by T_6 (12.19 leaves tiller^{-1}), T_5 (11.93 leaves tiller^{-1}), T_7 (10.48 leaves tiller^{-1}) and minimum was found in T_1 (9.08 leaves tiller^{-1}). Whereas after 90 days of first harvesting, it was ranged between 8.10 to13.44 leaves tiller^{-1} with significant results. The maximum number of leaves were found in T_8 (to13.44 leaves tiller^{-1}) followed by T_6 (11.43 leaves tiller^{-1}), T_5 (9.89 leaves tiller^{-1}), T_7 (9.48 leaves tiller^{-1}) and minimum was found in T_1 (8.10 leaves tiller^{-1}). In case of third growth phase it was ranged between 6.31 to 10.13 leaves tiller^{-1} at 75 DASH, where maximum was found in treatment T_8 (10.13 leaf tiller^{-1}) followed by T_6 (9.78 leaves tiller^{-1}), T_5 (8.51 leaves tiller^{-1}), T_7 (8.05 leaves tiller^{-1}) and minimum was found in T_1 (6.31 leaves tiller^{-1}). In second year the effect of fertilizer treatment on number of leaves per tiller followed same pattern also. Overall the results were found statistically significant ($P<0.05$ %). The number of leaves per tiller of plant followed the decreasing pattern in order of first, second and third harvesting (Fig. 2.2).

3. Clump diameter growth of *Cymbopogon flexuous*

In grasses the initiation of each tillers are responsible to increase the basal cover of the clump or whole plant. Thus higher clump diameter means higher potential of biomass production. The effect of cropping system, fertilizers and their interaction on *C. flexuosus* are presented here with table and figures.

Effect of cropping system: Effect of cropping system on clump diameter of *C. flexuosus* after planting is presented in figure 1.3. During first year the diameter of clump was 12.20 and 10.06 cm plant^{-1} whereas second year cropping season it was recorded 16.35 and 15.75 cm plant^{-1} for sole crop and in intercrop under agroforestry system respectively after 75 days of planting (DAP), while after 90 days of first harvesting, the diameter of clump per plant was available 11.12 and 9.57 cm plant^{-1} in first year of cropping whereas, second year it was recorded 12.61 and 11.84 cm plant^{-1} respectively for second harvesting. After 75 days of second harvesting these diameters were 8.58 and 7.08 cm plant^{-1} in first year, while second year it was recorded 11.84 and 9.93 cm plant^{-1} for sole crop and in intercrop for third harvest respectively. Clump diameter of *C. flexuosus* was higher under sole crop as compared to intercrop under agroforestry system in all the three growing phase and harvesting in both the cropping season with statistically significant results (P<0.05 %). The clump diameter of plant was higher in crop during first harvesting and it decrease sequentially during second and third harvesting.

Effect of Fertilizer **:** Effect of fertilizer on diameter of clump of *C. flexuosus* during first year showed that ranged between 8.40 to 14.27 cm plant^{-1} while second year it ranged between 15.07 to 17.38 cm plant^{-1} up to first harvesting (75 DAP). In first year of cropping the maximum diameter of clump per plant was found in treatment T_8 (14.27 cm plant^{-1}) followed by T_6 (13.45 cm plant^{-1}), T_5 (12.32 cm plant^{-1}), T_7 (11.17 cm plant^{-1}) and minimum was found in treatment T_1 (8.40 cm plant^{-1}) with statistically significant variations (P<0.05 %). Whereas after 90 days of first harvesting, it was ranged between 7.71 to 11.69 cm plant^{-1} and the maximum clump diameter per plant was found in T_8 (11.69 cm plant^{-1}) followed by T_6 (11.54 cm plant^{-1}), T_5 (11.19 cm plant^{-1}), T_7 (10.68 cm plant^{-1}) and minimum was found in treatment T_1 (7.71 cm plant^{-1}). In case of third growth phase it was ranged between 6.48 to 8.98 cm plant^{-1} at 75 DASH, where maximum was found in treatment T_8 (8.98 cm plant^{-1}) followed by T_6 (8.76 cm plant^{-1}), T_5 (8.51 cm plant^{-1}), T_7 (8.03 cm plant^{-1}) and T_3 (6.94 cm plant^{-1}) with minimum in T_1 (6.48 cm plant^{-1}). The effect of fertilizer treatment on clump diameter growth followed same pattern in second year of cropping also. Overall the results were found statistically significant (P<0.05 %). The clump diameter followed the decreasing pattern in order of first, second and third harvesting (Fig. 2.3).

4. Basal area per clump of *Cymbopogon flexuosus*

Basal area occupied the crop of *C. flexuosus* is important for growth vigour and production of biomass as well as essential oil. Thus higher number of tillers means maximum basal area of plant and more biomass production. The effect of cropping system, fertilizers and their interaction on basal area of plant of *C. flexuosus* are presented here with table and figures.

Effect of cropping system: Effect of cropping system on basal area per clump of *C. flexuosus* after planting is presented in figure 1.4. During first year the basal area was 121.51 and 81.04 cm^2 pant^{-1} whereas second year it was recorded 211.19 and 201.23 cm^2 for sole crop and in intercrop under agroforestry system respectively after 75 days of planting (DAP), while after 90 days of first harvesting, the basal area per plant in first year was available 98.73 and 74.62 cm^2 plant^{-1} whereas second year it was recorded 127.25 and 110.77 cm^2 respectively for second harvesting. After 75 days of second harvesting these area were recorded in first year 43.67 and 32.20 cm^2 plant^{-1} while second year it was observed 110.77 and 81.05 cm^2 for sole crop and in intercrop for third harvest respectively. Basal area of *C. flexuosus* was higher under sole crop as compared to intercrop under agroforestry system in all the three growing phase and harvesting in both the cropping year with statistically found significant (P<0.05 %). The basal area of clump was higher in crop during first harvesting and it decrease sequentially during second and third harvesting.

Effect of Fertilizer **:** Effect of fertilizer on basal area of clump per plant of *C. flexuosus* during first year showed that ranged between 60.01 to 164.47 cm^2 plant^{-1} while second year it was recorded 181.72 to 241.26 cm^2 plant^{-1} up to first harvesting (75 DAP). The maximum basal area of clump per plant was found in treatment T_8 (164.47 cm^2 plant^{-1}) followed by T_6 (144.91 cm^2 plant^{-1}), T_5 (121.09 cm^2 plant^{-1}), T_7 (100.69 cm^2 plant^{-1}) and minimum was found in T_1 (60.01 cm^2 plant^{-1}) with statistically significant variations (P<0.05 %). Whereas after 90 days of first harvesting, it was ranged between 55.66 to 109.76 cm^{2}plant^{-1} and the maximum basal area of clump per plant was found in T_8 (109.76 cm^2 plant^{-1}) followed by T_6 (105.05 cm^2 plant^{-1}), T_5 (102.22 cm^2 plant^{-1}), T_7 (92.80 cm^2 plant^{-1}) and minimum was found in T_1 (55.66 cm^2 plant^{-1}). In case of third growth phase it was ranged between 24.72 to 52.75 cm^2 plant^{-1} at 75 DASH, where maximum was found in treatment T_8 (52.75 cm^2 plant^{-1}) fallowed by T_6 (46.69 cm^2 plant^{-1}), T_5 (42.57 cm^2 plant^{-1}), T_7 (38.69 cm^2 plant^{-1}) and minimum was found in T_1 (24.72 cm^2 plant^{-1}). Overall the results were found statistically significant (P<0.05 %). The basal area of clump per plant followed the decreasing pattern in order of first, second and third harvesting.

In second year the effect of fertilizer treatment on basal area of clump per plant results followed same pattern also. Overall during all the three growth phase for three harvest the results were statistically significant (P<0.05 %). The basal area of clump per plant followed the decreasing pattern from first harvesting to third harvesting (Fig. 2.4).

Interaction of cropping system x fertilizer**:** Interaction of cropping system and fertilizer on crop of Lemon grass for number of tillers per plant, number of leaves per tiller, diameter of clump and basal area of clump etc. for both the cropping year showed statistically insignificant variations. Overall the interaction results were found statistically insignificant (P<0.05 %) variation for all the parameters observations except 60 days after first harvesting of grass. The number of tillers per plant, number of leaves per plant, clump diameter and basal area of clump was maximum during first phase of growth followed by second and third harvesting phase. The rate of growth was gradually decreased with age of grass in each harvesting (All Fig. of 1 & 2). During the second year the results showed same pattern along with maximum population of tillers was recorded higher during 2st year than 1st year of crop respective growth phases.

Tree and aromatic grass compete each other for soil moisture, nutrient and space, while the above ground competitions take place for light and space. The light intensity was found to be reduced beneath the tree resulting the suppressing effect on growth of aromatic grass. The reduction of number of tillers per plant, number of leaves per tiller, diameter of clump, and basal area of clump of *C. flexuosus* were observed under agroforestry where microclimatic condition are little bit changed due to canopy structure of trees. Here in present experiment, the variation in temperature relative humidity and PAR more during second year of crop because the tree canopy becomes large. Thus it is apparently reflected in growth behaviour of Lemon grass when compared with the crop of open plot. Many workers, Naugraiya and Pathak (2001), Venkata Rao *et al.* (2007), Vyas and Nein (1999) worked at the variation in climatic parameters due to tree. Density of tiller in a clump of Lemon grass was found less (12.05 to 18.02 %) under tree and it was also associated with clump diameter as well as basal area. Similar results were reported by Pareek and Gupta (1985) for Lemon grass when grown under *Terminalia arjuna*, Naugraiya and Pathak (2001) also noted similar behaviour in perennial grass species under *L. leucocephala* and *A. tortilis* based silvipasture system in Central India. The number of leaves per tiller in the clump was found maximum in sole crop in open field showed that the preference of light of the crop. Joy *et al*. (2006) also reported the requirement of light management during the cultivation of Lemon grass under agroforestry for quantitative results.

The number of harvests in a year depends on the climatic factors such as temperature, rainfall and humidity and level of soil fertility as well as cultivation and management practices. Generally three cropping cycle or seasons were found in humid condition for production of herb and oil in aromatic grasses (Farroqi and Sreeramu, 2001). In present experiment the crop was harvested three times or cropping season during two consequent years. The first harvest was done at 75 day after planting (September), second harvesting was done 90 day after first harvesting (December) and third or final harvesting was done in February *i.e.,* 75 day after second harvesting. Both immature and over mature crops give low yield and oil of poor quality (Farroqi and Sreeramu, 2001). The maximum growth of *C. flexuosus* was observed in first harvest *i.e.,* 75 days after plantation (July to September) in both the cropping years because this cropping season have moderate PAR and temperature with high relative coupled with suitable soil moisture resulting high rate of photosynthesis in the plants particularly C_4 plant species (Beech, 1977). Growth pattern was found in decreasing order during second and third cropping season because the relative humidity and soil moisture was found to be consistently decreasing. In case of decline in herbage growth of *C. flexuosus* with intercropping of tree might be due to decreased the vital activities of plant with increasing the comparative dryness in climate as well as in plants (Duriyprapan and Britton, 1982), in red lateritic soil another reason for significant reduction in herb yield might be attributed to the lower fertility status build-up in root zone during the second and third cropping seasons. The dynamic change in electrolyte conductivity in root zone soil layer was occurred with dryness of soil (Naidu and Rengasamy, 1993). These findings are in conformity with those of (Rousseva, 1970; Faize Mohsin and Singh, 2007).

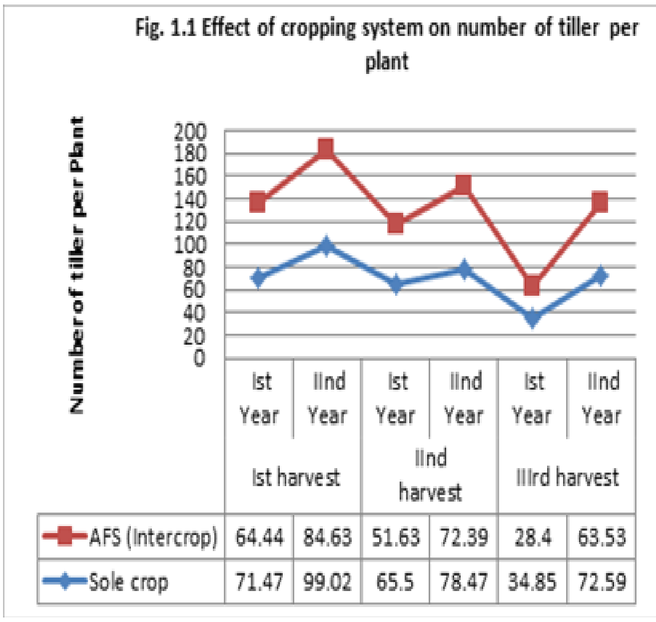
Urea fertilizer significantly increased the fresh and dry herbs yield of plants compared to the control treatment. In the first season the dry herbs increased over control by N, NP, NK and NPK doses of fertilizer. Nitrogen uptake increased significantly with all the fertilizer as compared with control during three seasons. Similar results had been reported by Ram *et al.* (1989) on Japanese mint, Singh and Singh (1992) on Citronella grass.

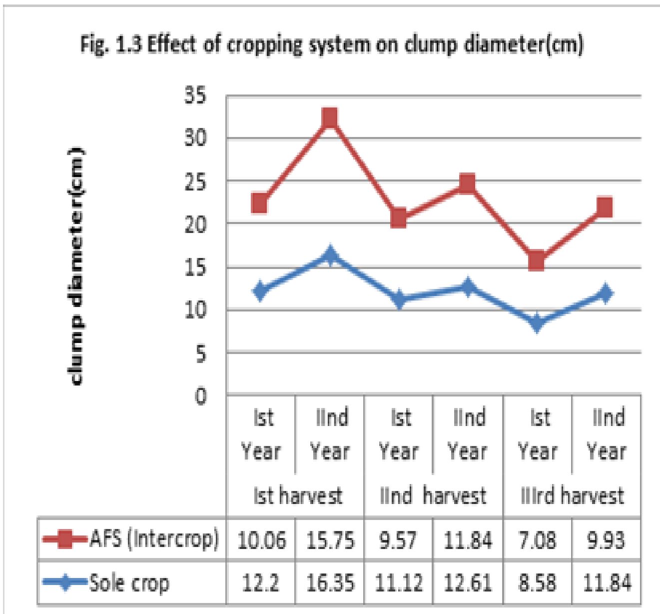
Application of NPK gave positive results for performance of growth parameters. However the different combination of NPK (30 kg N, 20 kg P & K) showed that application of NPK as individual fertilizer did not found effective as compare to combination of two fertilizers and all three fertilizers in red lateritic soil. The combined application of N and K was more effective as compare to N & P and P & K. Parbery *et al.* (1968) reported that apart from N the K is also necessary for higher production of Lemon grass in their study of nutrient uptake and removal from the soil. Similar observations were also reported by Beech (1977).

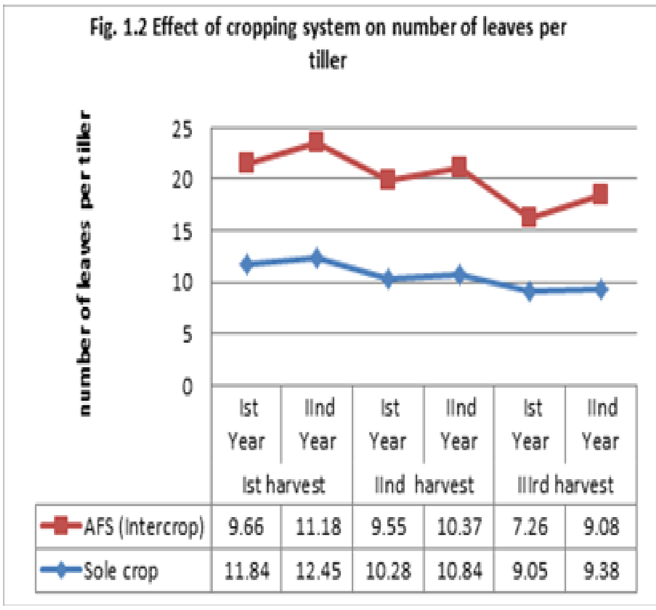
Population of tillers, number of leaves per tiller, clump diameter and basal area of clump of Lemon grass with statistically significant differences was found maximum on application of 30 kg N and 20 kg P and K per ha and minimum in without application of NPK. Yadava (1999 & 2000) reported in his studies on Lemon grass at different fertility levels with Poplar for two years, which the application of NPK fertilizer gave good response in respect of number of tiller, plant height, herbage yield and oil content when higher doses of all three were applied. Similar results were observed by Gajbhiye *et al.* (2013) who investigated that significantly lower number of tillers per clump was observed in plants without application of fertilizer and also reported that the number of leaves per clump of lemongrass was significantly higher in plants applied inorganic fertilizer and farmyard manure together. Moreover, Singh (1998) reported the favourable effect onnumber of tillers per clump at fertilizer level 100 kg N/ha. In the present study the compact effect of moisture and nutrient was found to be responsible for mortality of tillers. Poor response of Lemon grass and Palmarosa to N- application has also been reported by Maheshwari *et al.* (1984), Patra *et al.* (1989) and Prasad & Mukherjee, 1980. Effect of fertilizer on Lemon grass was found significant, however nitrogen is an important nutrient but presence of potassium played on important role for enhancing the yield of herbs and oil. Maheshwari *et al.* (1984) reported appreciable increases in the yields of Lemon grass on application of nitrogenous fertilizers, but they found the 30 kg N ha^{-1} as optimum dose. Dhahotonde and Fasate (1988) reported that application of N with P had no effect on quantity and quality of Lemon grass oil. Similar resulted had also been reported by Ram *et al.* (1989) on Japanese Mint, Singh and Singh (1992) on *Citronella java*, Singh *et al.* (1997) on *Coriandrum sativum* and Singh (1999) on *Pelargonium graveolens.* Satyabrata Maiti (2004) reported that higher doses N produced significantly highest number of leaves per clump over control. Prasad and Mukharjee (1980) recommended 40 kg N/ha and 40 kg P_2O_5 /ha for higher yields of Lemon grass.

Effect of Interaction of cropping system and levels of NPK fertilizer on Lemon grass growth and production behaviour were found better sole crop with application of $N_{30}P_{20}K_{20}$ fertilizer and minimum in crop under agroforestry with no fertilizer in all the three growths and harvesting period during both the years with insignificant results. Analogous results were also found by Chauhan (2003) when growing of numerous medicinal and aromatic plants under Poplar and *Eucalyptus hybrid* plantations. The application on

NPK fertilizers gave significant results for almost all the growth characteristics. But the interaction of cropping system and fertilizer were not found effective and showed statistically insignificant variation was found for herbage production. More or less similar in open sole crop and intercrop under agroforestry system. In agroforestry system crop performance was found to be declined due to competition for light and temperature at above ground level (Hasan, 2007), light and temperature very important and limiting factor for photosynthesis, for food and other metabolic activities to produce oil or other important specific material inside the plant (Kushwaha, 2001). But in red lateritic wastelands where the productivity level is reported very poor, the cultivation of commercial grass species under MPTs plantation with optimum application of NPK fertilizers in rainfed environment can be an ecofriendly practices to conserve the soil, water, surrounding climate with less interference of bovine population and marginal economic gain (Pathak and Naugraiya, 1995; Thakur and Dutt, 2007).







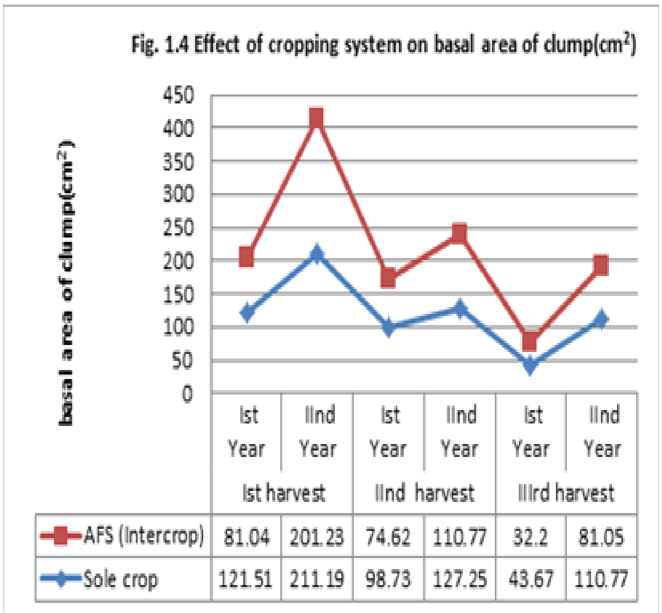


Fig. 1 : Effect of cropping system on growth performance on *Cymbopogon flexuosus* under agroforestry system and sole cropping

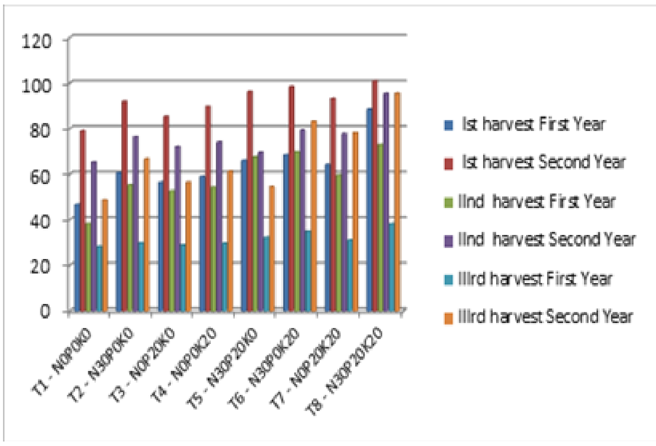


Fig. 2.1 : Effect of fertilizer on number of tiller per plant

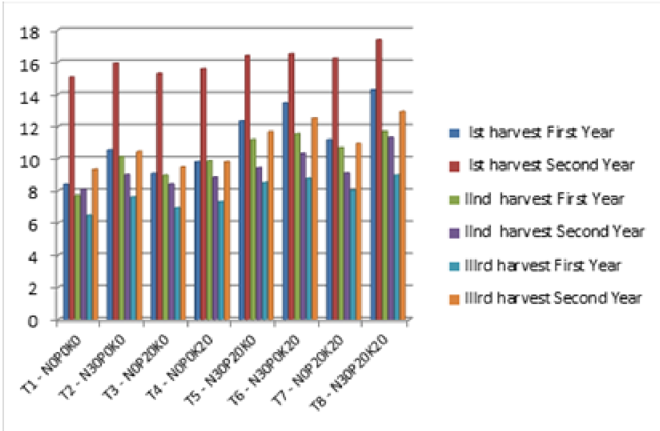


Fig. 2.3 : Effect of fertilizer on clump diameter (cm)

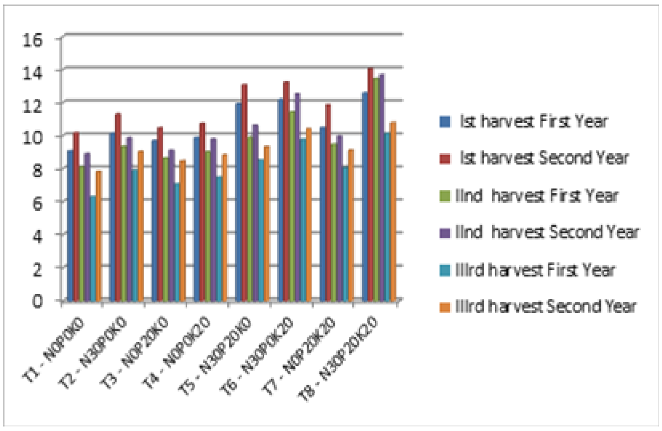


Fig. 2.2 : Effect of fertilizer on number of leaves per tiller

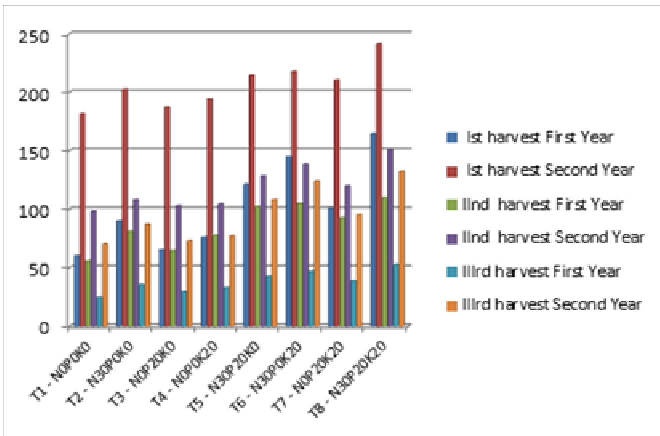


Fig. 2.4 : Effect of fertilizer on basal area of clump (cm^2)

Fig. 2 : Effect of fertilizers on growth performance on *Cymbopogon flexuosus* under agroforestry system

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REFERENCES

Baser, K.H.C. and Buchbauer, G. (2015). Hand book of essential oil: Science, technology and applications. 2 *Ed.* Boca Raton, CRC Press, Taylor & Francis Group.

Beech, D.F. (1977). Growth and oil production of Lemon grass (*Cymbopogon citratus*) in the Ord irrigation area, Western Australia. *Aus. J. Arg*., 17: 301-307.

Charles, D.J. (2012). Lemongrass. In: antioxidant properties of spices, herbs and other sources. Springer, New York; 377- 383.

Chauhan, H.S. (2003). Growing medicinal and aromatic crops under well develop Poplar and Eucalyptus plantation. In: National Symposium on Agroforestry in 21st Century, Ludhiana, February, 11-14, Abstrct. Ludhiana, P. A. U.-9.

Dhantonde, B.N. and Fasate, S.N. (1988). Effect of N and P on Lemon grass (*Cymbopogon spp.*) in relation to oil and its quality. *PKV Res.* J (India) 10(2): 152-153.

Dhyani, S.K. (2018). Agroforestry in Indian Perspective. Rajeshwar Rao G, Prabhakar M, Venkatesh G, Srinivas I and Sammi Reddy K (Eds.). Agroforestry Opportunities for Enhancing Resilience to Climate Change in Rainfed Areas, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, India. p. 224.

Duriyprapan, S. and Britton, E.J. (1982). The effect of solar radiation on plant growth, oil yield and oil quality of Japanese mint. *Journal of Botany*, 58: 729-736.

El-Sayed, A.; El-Leithy, A.S.; Swaefy, H.M. and Senossi, Z.F.M. (2018). Effect of NPK, Bio and Organic Fertilizers on Growth, Herb Yield, Oil Production and Anatomical Structure of (*Cymbopogon citratus*, Stapf) Plant. *Annual Research & Review in Biology*, 26(2): 1-15.

Faiz, M.; Singh, P.R.; Singh, K. and Mohsin, F. (1996). Growth and biomass production by *populus deloides* under agroforestry in Tarai of Kumaun Region, U.P. *Indian Forester*, 122(7): 631-636.

Farooqi, A.A. (2004). Cultivation of Medicinal and Aromatic Crops Published by *Universities press (India) private Limited* 3-5-819 Hyderguda, Hyderabad.

Farooqi, A.A. and Sreeramu, B.S. (2001). History, importance, present status and future prospects of medicinal crops Cultivation of Medicinal and Aromatic Crops 200; Hyderabad Universities press pp. 1–19.

Gajbhiye, B.R.; Monin, Y.D. and Puri, A.N. (2013). Effect of FYM and NPK fertilization on growth and quality parameters of lemongrass (*Cymbopogon flexuosus*), *Agricultural Science research Journal,* 3(4):115-120.

Gawali, A.S. and Meshram, N.A. (2019). Scientifically cultivation of lemon grass -a potential aromatic crop. *Plant Archives,* 19(2): 2860-2864.

Gupta, M.K. and Sharma, S.D. (2009). Effect of tree plantation on soil properties, profiles morphology and productivity index- II. Poplar in Yamunanager district of Haryana. *Ann. For.,* 17(1): 43-70.

Hasan, A.; Kumar, A.; Kumar, P. and Abbas, Z. (2007). Effect of nitrogen levels on growth herb yield and essential oil content of *Ocimum basilicum* var gabratum (Sweet basil). *Indian Journal of Tropical Biodiversity*, 15(2): 140-143.

Huda, S.M.S.; Sujauddin, M.; Shafinat, S. and Uddin, M.S. (2007). Effects of phosphorus and potassium addition on growth and nodulation of *Dalbergia sissoo* in the nursery. *J. For. Res.,* 18: 279-282.

Joy, P.P.; Baby, P.S.; Mathew, S.; Mathew, G. and Joseph, A. (2006). Lemon grass: The fame of Cochin. *Indian J. Arecanut, Spices and Medicinal Plant,* 8 (2): 55-64.

Kushwaha, S.K. (2001). Growth, biomass production and nutrient distribution in age series of *Gmelina arborea* L. plantation as monoculture and agrisilviculture system. *M. Sc*. Thesis submitted to IGKV, Raipur, 112-113.

Maheshwari, S.K.; Yadav, S. and Gupta, R.S. (1984). Fertilizer needs of Palmarosa oil grass (*Cymbopogon martini* stapf var motia) under rainfed condition in M.P. Indian perfumer, 28(2): 77-81.

Mutanal, S.M., H.Y. Patil and M. V. Mokashi (2016). Economic evaluation of multi purpose tree species in degraded lands of Karnataka. *Internat. J. Forestry & Crop Improv.,* **7**(1) : 35-40.

Naidu, R. and Rengasamy, P. (1993). Ion interaction and constraints to plant nutrition in Australian sodic soil. *Aust. J. Soil. Sci*., 31: 801-819.

Naugraiya, M.N. and Pathak, P.S. (2001). Diversity of herbage species under silvipastoral system. *Indian J. Agroforestry,* 13(2): 154-158.

Parbery, D.B.; Rose, C.W. and Stern, W.R. (1968). Characteristics of the three main agricultural soils in the lower ord River Valley, Western Australia, C.S.I.R.O., Division of Land Research, Technical Memorandum 68/7.

Pareek, S.K. and Gupta, R. (1985). On the status of agronomic research in *Cymbopogon flexuosus* in India with projection on future work. *Indian perfumer*, 29: 215-224.

Pathak, P.S. and Naugraiya, N.N. (1995). Improvement and management of degraded lands for Eco-restoration. *Environment: Some Focal Issues*, 17-77.

Patra, D.D.; Singh, K. and Singh, D.V. (1989). Agronomy of *Cymbopogon spp*. CROMAP. 11(2) : 72-80.

Pofali, R.M. and Bhattacharjee, J.C. (1970). Terrain analysis of Amnernasin. *Journal of Indian Society of Soil Science,* 18: 279-287.

Prasad, L.K. and Mukherjee, S.K. (1980). Effect of N, P and K on Lemon grass. *Indian J. Agron*., 25: 42-44.

Premathilake, U.G.A.T.; Wathugaala, D.L. and Dharmadasa, R.M. (2018). Effect of different fertilizers on crop growth, oil yield and chemical composition of lemongrass (*Cymbopogon citrates* (DC.) Stapf). *The Journal of Agricultural Sciences-Srilanka*, 13(3): 254-262.

Rajeshwar Rao, B.R.; Chand, S.; Bhattacharya, A.K.; Kaul, P.N.; Singh, C.P. and Singh, K. (1998). Response of lemongrass (*Cymbopogon flexuosus*) cultivars to spacing and NPK fertilizers under irrigated and rainfed conditions in semi-arid tropics. *Journal of Medicinal and Aromatic Plants Sciences*, 20: 407-412.

Ram, M.; Yadav, R.L.; Chatterjee, B.N. and Singh, D.V. (1989). Relative efficacy of nitrogen carriers at different rates and times of application on growth and yield of Japanese mint (*Mentha arvensis*). *Indian J. Agric. Sci.,* 59(4): 236-241.

Rousseva, E.D. (1970). Effect of light of different spectral regions on the growth and tarpene biosynthesis in Mentha Piperata L. Competes. Rendus De L. Academic Des. *Sciences Aricoles Evi*. Bulgaria. 3: 5-9.

Satyabrata, M. (2004). Annual Report. National Research Centre for medicinal and Aromatic Plants. *Anand Press*, Anand , Gujrat.

Sharanabasappa, A.P.; Madiwalar, S.L.; Channabasappa, K.S. and Kumar, P. (2007). Performance of Medicinal and Aromatic Plants as Intercrops with Teak. *Karnataka J. Agric. Sci.,* 20(1): 179-180.

Sharma, R.; Kumar, S.; Thakur, K.S. and Kumar, S. (2007). Estimates of genetic parameters from an open pollinated progeny test of Shisham (*Dalbergia sissoo* Roxb.). *Indian J. For.*, 30(3): 273-278.

Singh, A. and Kumar, A. (2017). Lemongrass (*Cymbopogon flexuosus*) Cultivation, Oil Extraction and Chemical Composition in Kannauj Region (U.P). *International Journal of Innovative Research in Science, Engineering and Technology*. Vol. 6, Issue 7.OI:10.15680/IJIRSET.2017.0607180

Singh, A.K. and Totey, N.G. (1985). Physico-chemical properties of Bhata soils of Raipur (C.G.) as affected by plantation of different tree species. *Journal of Tropical Forestry,* 1: 61-69.

Singh, K. and Singh D.V. (1992). Effect of rates and sources of nitrogen application on yield and nutrient uptake of Citronella Java (*C. winterianus*). *Fertilizer Research,* 33: 187-191.

Singh, K.; Kothari, S.K.; Singh, D.V.; Singh, V.P. and Singh, P.P. (2000). Agronomic studies in *Cymbopogon - A review spices and aromatic crops*. 9(1):13-22.

Singh, K.A. (1999). Impact of various landuses on soil properties of sloping hills in Sikkim, Eastern Himalaya. *Indian Journal of Soil Conservation.* 27(1): 70-73.

Singh, M. and Singh, C.P. (1998). Growth and yield response of lemongrass (*Cymbopogon flexuosus*) to nitrogen, *Journal of Medicinal and aromatic Plants Science*, 20: 383-385.

Singh, M.; Ravindra, N.S. and Chander, P.K. (1997). Effect of irrigation regime on yield of Lemon grass (*Cymbopogon flexuosus*). *Indian Journal of Agricultural Sciences,* 67(2): 79-80.

Singh, R.; Rajat, S.P. and Banerjee, S. (2009). Growth performance of multipurpose tree species in degraded land under agroforestry practices, *J. Tropi. Forest.*, 25(1 & 2): 25-29.

Subba, R.; Venkateshwarlu, G. and Shanker, G.R.M. (1991). Green leaf manuring as an alternative nitrogen source for castor bean on marginal soil of India. *American J. Alternative Agric.*, 6: 132-138.

Thakur, P.S. and Dutt, V. (2007). Cultivation of Medicinal and Aromatic Herbs in Agroforestry for Diversification under Submontane Conditions of Western Himalayas. *Indian Journal of Agroforestry*. 9(2): 67-76.

Venkata Rao, M.; Patil, S.J. and Sumanthkumar, K. (2007). Effect of photosynthesis active radiation on yield of Groundnut in Teak based agroforestry system. *Karnatka J. Agric. Sci*., 20(3): 605-607.

Vyas, S. and Nein, S. (1999). Effect of shade on the growth of *Cassia angustifolia*. *India forester,* 125: 407-410.

Yadava, A.K. (1999). Effect of spacing and fertility levels on Lemon grass (*Cymbopogon flexuosus*) Poplar based agroforesty system. *Advance in Forestry Research in India.* Vo.l XX. pp 70-85.

Yadava, Y.K. (2000). Cultivation of Lemon grass (*Cymbopogon flexuosus* 'CKP-25') under Poplar based agroforestry. *Indian Forestry,* 127(2): 213-223.