PRODUCTIVITY AND NUTRIENT DYNAMICS IN VIGNA MUNGO AND TRITICUM AESTIVUM GROWING IN AN AGROFORESTRY SYSTEM IN HIMACHAL PRADESH

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ABSTRACT

The present investigation was aimed at analyzing growth, biomass, productivity and nutrient status in Vigna mungo and Triticum aestivum growing in traditional agroforestry system in Solan (HP). Vigna mungo showed grain yield of 13.63 Mg/ha, straw yield of 7.87 Mg/ha and harvest index of 63.93 % whereas Triticum aestivum showed grain yield of 25.40 Mg/ha, straw yield of 23.50 Mg/ha and harvest index of 51.84 % for the consecutive two study years. Total biomass of 33.34 Mg/ha and 74.63 Mg/ha was found in Vigna mungo and Triticum aestivum respectively. Organic C, N, P and K distribution at soil depths of 0-15, 15-30 and 30-60 cm were also studied. The physico-chemical properties of soil revealed that pH increased from 7.77 to 8.02 and 7.60 to 7.87, electric conductivity decreased from 0.22 to 0.15 and 1.18 to 1.06 in Vigna mungo and Triticum aestivum, respectively. Bulk density also decreased from top to bottom. Organic carbon showed a depth wise decrease from 0.73 to 0.51 and 0.60 to 0.47 as well as potassium also showed same trend of decrease 51.65 to 39.84 and 91.18 to 54.02 in Vigna mungo and Triticum aestivum, respectively. Nitrogen showed depth wise increase. Phosphorus also showed an increase from 0.21 to 0.31 in Triticum aestivum but showed reverse trend in case of Vigna mungo.

KEYWORDS: Agroforestry System, Growth, Biomass, Nutrient Dynamics, Productivity

INTRODUCTION

Agroforestry is a unique and common practice in the sub-temperate mid-hills of Himachal Pradesh, India. The agrihortisilviculture is a common practice by the farmers which includes the cultivation of agricultural crops in association with forest and horticultural trees. The arrangement of agrihortisilviculture (agricultural crops + horticulture tree + forest tree) systems on the same piece of land provides the stable and better output to the farmers. It is worthwhile, that in hilly regions the existence without agroforestry is difficult because trees not only supplement the fodder, fuel, fiber, fruits etc. but also reduces the pace of land sliding in the fields, protect crops to adverse wind and climatic conditions, conserve the moisture, improve the soil quality through nitrogen fixation and organic matter in terms of leaf fall etc. In the Himalayan region, a number of indigenous agroforestry systems have been familiar from Himachal Pradesh and Uttarakhand (Atul et al., 1990) out of which agrihortisilviculture, agrisilviculture and agrihorticulture are frequent. Singh et al. (1980), Dadhwal et al. (1989) and Toky et al. (1989) have recognized these three agroforestry systems with their multifarious benefits. Agroforestry was recognized by IPCC as having high potential for sequestering C as part of climate change mitigation strategies (Watson et al., 2000).

It can increase and stabilize agricultural yields and reduce soil erosion (Prinsely, 1990). Rana et al. (1988) reported the species composition, biomass, and productivity patterns of three types of traditional agroforestry systems namely, agrisilviculture, agrihorticulture, and agrihortisilvicultural, commonly practiced in the western Himalaya. Among three systems agrihortisilvicultural was highly diverse in vegetation, with as many as 13 tree and 5 agricultural crops mixed
This system showed the highest productivity up to 25.8 t ha\(^{-1}\) yr\(^{-1}\), out of which 68 percent was contributed by the trees and the remainder by the annuals. Agrisilviculture system having predominantly annuals had the lowest productivity of 20.4 t ha\(^{-1}\) yr\(^{-1}\) with only 27 percent contribution by the trees.

Nutrient distribution in the vegetation and soil compartments provides useful information on nutrient budgeting of the ecosystem (Das and Ramakrishnan, 1987; Bargali et al., 1992; Shanmughavel et al., 2001). The understanding of nutrient accumulation and storage processes help in evolving suitable strategies of nutrient management for maximizing biomass production. The management of organic C and nutrient pools in soil is crucial as it not only affects the plants survival and its growth but also influences its productivity. In a given climate, the carbon accretion depends on the soil organic matter and availability of nutrients, which in turn depends on the pattern and role of their cycling (Rawat and Singh, 1988). The present investigation is an effort to examine the productivity and nutrient dynamics of agricultural crops in the existing agrihortisilviculture system in sub- temperate mid-hills of Himachal Pradesh.

**MATERIAL AND METHODS**

The present investigation on growth, biomass, productivity and nutrient distribution was carried out in the existing agroforestry system in sub-temperate midhills of Himachal Pradesh for the year 2010-2011 and 2011-2012. The study was carried out in Solan district of Himachal Pradesh, which lies between 30\(^{\circ}\) 50’30”-30\(^{\circ}\) 52’0” N latitudes and 77\(^{\circ}\) 8’30”-77\(^{\circ}\)11’30” E longitude (Survey of India Top sheet No. 53F/1). It is classified in Zone-II, sub-temperate and sub-humid, midhills category. Study site within the vicinity of Shoolini University at a distance of 4 km was selected. The random selection of the samples of agriculture crops was done from the study site.

**Study Site**

Study site chosen for the present work is village Sultanpur where agroforestry practices are followed traditionally. It is a combined production system integrating agricultural crops as well as forest. The prominent tree species, crops, vegetables and fruits grown in the study area are: Grewia optiva Drumm. (Beul), Bauhinia variegata Linn. (Kachnar), Celtis australis Linn. (Khirak) and Toona ciliata Roxb. (Toon), Triticum vulgare (Wheat), Brassica compestris (Sarson), Lycopersicon esculentum (Tomato), Capsicum annuum (Shimla - mirch), Zea mays (Maize), Vigna mungo (Black gram), Pisum sativum (Pea), Pyrus communis Linn. (Nashpati) and Punica granatum Linn. (Daru). The agricultural fields are terraced with trees growing along boundaries but with no regular sequence.

**Growth, Biomass and Yield Attributes of Vigna mungo and Triticum aestivum**

Five quadrates of 50x50 cm in triplicates were laid in agroforestry area. Agricultural crops from the laid quadrates were harvested at the time of maturity and separated into grain (seeds) and straw (vegetative portion including shoots and leaves). Crop height, crop density, number of leaves per plant, number of pods/spikes per plant, and number of grains per plant were measured. Fresh and dry weight of crop was also taken for biomass estimation. On maturity, the crops were harvested from the sample plots (50 x 50 cm). Threshing and cleaning of the seeds was done manually and weighed. Number of grains per plant was counted. The average grain yield and straw yield was finally determined. Harvest index (HI) was calculated following Khandakar (1985):

\[
\text{Harvest Index} = \frac{\text{Grain yield}}{\text{Biological yield (grains + straw)}} \times 100
\]

Cultural operations followed in Vigna mungo and Triticum aestivum were as per the package of practices followed in Dr. Y. S. Parmar University of Horticulture, Solan (Anon 2006).
Soil Nutrient Analysis

Soil samples were collected randomly from the study site at 0-15 cm, 15-30 cm and 30-60 cm depths. Samples in five replications of each soil depth at the study site were analyzed for the distribution of nutrient elements and other parameters. Collected soil samples were dried, ground with mortar and pestles and sieved through 2 mm mesh before analysis of physical and chemical parameters. Soil at different depths of selected site was analyzed for pH, electric conductivity, bulk density, % organic carbon, available N, P and K. pH and electric conductivity were measured following the method of Jackson (1973) and bulk density was measured by specific gravity bottle method given by Singh (1980). Organic carbon was analysed following the Walkley-Black Method (1965). Nitrogen was estimated by Micro-Kjeldhal method given by Chapmann and Pratt (1961). Potassium and Phosphorus were analysed by Flame Photometer following method of Jackson (1967) and spectrophotometrically by Watambe and Olsen (1965) method, respectively.

RESULTS AND DISCUSSIONS

Growth and yield attributes of *Vigna mungo* and *Triticum aestivum* are given in Table 1. It is evident that in *Vigna mungo* there is no variation in the height of plants under tree system or as a sole crop however in *Triticum aestivum* it varied and the growth was comparatively much better without tree system. No statistical variation in crop density was found between two crops growing under agroforestry system or as sole crop. A significant variation in grain yield, number of pods and number of grains was evident in the presence and absence of trees. In *Vigna mungo* productivity was almost 1.76 times more in the sole crop as compared to crop growing under tree system; however in *Triticum aestivum* this variation was comparatively less 1.28 times more as a sole crop. Note much variation in Harvest index was found in trees grown in agroforestry system; however in *Triticum aestivum* this variation was 1.32 times more in the sole crop.

The physico-chemical properties of soil in *Vigna mungo* and *Triticum aestivum* grown in agroforestry system at 0-15, 15-30 and 30-60 cm depths of soil revealed that soil pH increased whereas electric conductivity and bulk density decreased from top to bottom. Organic carbon, phosphorus and potassium showed a decrease whereas reverse trend was observed in nitrogen in *Vigna mungo*. pH increased from 7.77 to 8.02 and 7.60 to 7.87, electric conductivity decreased from 0.22 to 0.15 and 1.18 to 1.06 in *Vigna mungo* and *Triticum aestivum* respectively. Bulk density also decreased from top to bottom and it was 1.13 to 1.07 and 0.61 to 0.51 in *Vigna mungo* and *Triticum aestivum*, respectively. Organic carbon and potassium showed a depth wise decrease from 0.73 to 0.51 and 0.60 to 0.47 and potassium from 51.65 to 39.84 and 91.18 to 54.02 in *Vigna mungo* and *Triticum aestivum*, respectively. Nitrogen showed deep wise increase from 329.59 to 383.29 and 262.73 to 311.97 in *Vigna mungo* and *Triticum aestivum*, respectively. Phosphorus also showed an increase from 0.21 to 0.31 in *Triticum aestivum* but showed reverse trend in case of *Vigna mungo* as is evident from figures 1-7.

Table 1: Growth and Yield Attributes of *Vigna mungo* and *Triticum aestivum* in Agroforestry System

<table>
<thead>
<tr>
<th>Parameters</th>
<th><em>Vigna mungo</em></th>
<th><em>Triticum aestivum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>with Tree</td>
<td>without Tree</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>78.18±6.17</td>
<td>78.81±5.05</td>
</tr>
<tr>
<td>Crop density (m²)</td>
<td>11.40±0.50</td>
<td>12.60±0.60</td>
</tr>
<tr>
<td>No. of leaves per plant</td>
<td>14.83±0.13</td>
<td>13.61±2.80</td>
</tr>
<tr>
<td>No. of pods/spikes per plant</td>
<td>10.26±0.36</td>
<td>12.38±0.72</td>
</tr>
<tr>
<td>No. of grains per plant</td>
<td>69.88±2.38</td>
<td>111.62±0.18</td>
</tr>
<tr>
<td>Grain yield (Mg/ha)</td>
<td>13.63±1.13</td>
<td>23.58±2.33</td>
</tr>
<tr>
<td>Straw yield (Mg/ha)</td>
<td>7.87±0.47</td>
<td>12.62±0.98</td>
</tr>
</tbody>
</table>
Table 1: Contd.,

<table>
<thead>
<tr>
<th>Harvest index (%)</th>
<th>63.93±1.03</th>
<th>65.1±0.50</th>
<th>51.85±0.15</th>
<th>52.8±0.53</th>
</tr>
</thead>
</table>

± Standard error

Table 2: Biomass Attributes of Vigna mungo and Triticum aestivum in Agroforestry System

<table>
<thead>
<tr>
<th>Biomass (Mg/ha)</th>
<th>Vigna mungo with Tree</th>
<th>Vigna mungo without Tree</th>
<th>Triticum aestivum with Tree</th>
<th>Triticum aestivum without Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>9.69±0.75</td>
<td>12.32±1.58</td>
<td>15.61±4.93</td>
<td>13.98±1.22</td>
</tr>
<tr>
<td>Shoot</td>
<td>13.86±3.08</td>
<td>12±2.60</td>
<td>21.6±6.90</td>
<td>23.56±2.44</td>
</tr>
<tr>
<td>Root</td>
<td>1.65±0.017</td>
<td>1.25±0.15</td>
<td>14.17±3.29</td>
<td>13.08±2.52</td>
</tr>
<tr>
<td>Pod /Spikes</td>
<td>8.12±0.22</td>
<td>12.62±0.98</td>
<td>23.26±1.55</td>
<td>28.63±2.00</td>
</tr>
<tr>
<td>Total</td>
<td>33.34±2.10</td>
<td>38.19±0.11</td>
<td>74.63±13.57</td>
<td>79.25±4.18</td>
</tr>
</tbody>
</table>

± Standard error

The impact of agroforestry systems on soil fertility has been shown by various workers from coconut growing areas in terms of higher organic matter content, total nitrogen, available phosphorus and potash in the top soil, and improved microbial activities in the system (Varghese et al., 1978; Bavappa et al., 1986; Liyanage, 1994; Dagar, 1995a, b). Quantity of litter fall, its chemical composition, nutrient addition and change in chemical composition of soil were studied by Singh et al. (1989) under agroforestry systems involving Populus deltoides and Eucalyptus hybrid tree with intercrops of aromatic grasses Cymbopogon martini and C. flexuosus in the tarai tract of Kumaon hills. On an average, dry litter production of Populus deltoides was 5 kg tree⁻¹ yr⁻¹ whereas of Eucalyptus hybrid 1.5 kg tree⁻¹ yr⁻¹. Under the canopies of these two trees soil organic carbon enhanced by 33 to 38 percent and available nitrogen by 38.1 to 68.9 percent over control in 0-15 cm soil layer. There was significantly higher fertility build up under Populus deltoides than Eucalyptus hybrid.

The productivity (biomass) of trees is influenced by availability of nutrients which in turn depends on the pattern and role of their cycling. Understanding of nutrient accumulation and storage processes helps in evolving strategies of nutrient management for maximizing biomass production. Earlier Swamy et al. (2003) have studied the growth, biomass, carbon storage and nutrients (N, P and K) variations in 1 to 6 years-old chronosequence plantations of Gmelia arborea. Soil organic carbon increased from 8.46 to 14.02 Mg ha⁻¹ within 6 years. At soil depths 0-20 cm, 21-40 cm and 41-60 cm, available N enhanced by 14.85 percent, 11.98 percent and 11.25 percent, K by 10 percent, 9.13 percent and 10.63 percent, whereas P declined by 26 percent, 23 percent and 20 percent, respectively. Lal (1989) also observed the changes in soil organic carbon and nutrient status under different management system. He found that over a period of six year (12 cropping seasons), the relative rates of decline in the status of nitrogen and organic carbon was much less under alley cropping of Leucaena and Gliricidia as compared to normal arable crops.

Kohli et al. (1996) evaluated the performance of seven winter season crops (Triticum aestivum, Cicer arietinum, Lens culinaris, Avena sativa, Trifolium alerandrum, Brassica compestris and Pisum sativum) under 6 year-old P.deltoides plantation. Germination, plant height, biomass and relative growth rate of crops were significantly reduced under P.deltoides plantations compared with sole crops (without trees). Similarly, Burgess et al. (2004) evaluated the productivity of wheat (Triticum aestivum), barley (Hordeum vulgare), field beans (Vicia Faba), peas (Pisum sativum) and mustard (Brassica alba) under four poplar hybrids (Beaupre, Trichobel, Robust, Gibeq) planted at 10m x 6.4 m in three contrasting low land sites in England. Across three sites, in the presence of trees, the yield per unit cropped area relative to the crop yield in the control areas, was an average of 4 per cent less in the first three years and an average of 10 percent less between years four and six. The benefits of preceding fallow, rather than a cereal crop, for yields were greatest for wheat (Triticum aestivum), barley (Hordeum vulgare), and least for field beans (Vicia Faba), peas (Pisum sativum) and
mustard (*Brassica alba*). The yields of all these crops were greater in 1st year under poplar clones in comparison to sole crops. Also, Swamy and Puri (2005) reported the productivity of crops in agrisilviculture system. Under 5-year old stands of *G.arborea* stands, the reduction in grain yield was maximum in urd (65 %) followed by mung bean (59 %) and cowpea (34 %) during rainy season. Soybean had the lowest yield losses (25 % grain yield loss and 26 % straw yield loss in 5-year-old stands). Both straw and seed yield losses were more than two times higher in mung and urd crops compared to soybean. In the winter season, the chickpea exhibited highest yield reduction followed by linseed and mustard. The yield losses were lowest in wheat as compared to other crops. Under 5-year old stands of *G.arborea* stands, the reduction in grain yield in different crops was in the order: chickpea (36 %) > linseed (16 %) > mustard (14 %) > wheat (7 %). Similarly reduction in the straw yield was in the order: chickpea (20 %) > mustard (9 %) > linseed (6 %) > wheat (4 %). In 5-year-old stands of *G.arborea*, the grain and straw yields of chickpea reduced by five times as compared to wheat.

It is pertinent to mention that in *Vigna mungo* productivity was almost 1.76 times more in the sole crop as compared to crop growing under tree system; however in *Triticum aestivum* this variation was comparatively less which is 1.28 times more as a sole crop. *Vigna mungo* improved productivity through increased soil nutrient specially nitrogen and organic carbon as compared to *Triticum aestivum.*

![Figure 1: pH at Different Soil Depths](image1)

![Figure 2: Electric Conductivity at Different Soil Depths](image2)

![Figure 3: Bulk Density at Different Soil Depths](image3)

![Figure 4: % Organic Carbon at Different Soil Depths](image4)

![Figure 5: Amount of Nitrogen at Different Soil Depths](image5)

![Figure 6: Amount of Phosphorus at Different Soil Depths](image6)
Figure 7: Amount of Potassium at Different Soil Depths

REFERENCES

Productivity and Nutrient Dynamics in *Vigna mungo* and *Triticum aestivum* Growing in an Agroforestry System in Himachal Pradesh

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