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Assessment of soil fertility using *Ageratum conyzoides* in mid-hills of Arunachal Pradesh

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ABSTRACT

Growers of the hill ecosystem, assess soil fertility by visualizing the luxuriant growth of weeds (*Ageratum conyzoides*). Since a long time, they have been using this as a soil fertility indicator as indigenous knowledge. Thus, the present study was conducted to quantify weed density, crop performance, soil fertility status and correlate with growers view by enquiring from respondents. A total of 78 respondents were interviewed and their responses were filled in unorganized questioners. The major parameters *viz.* weed density, rice grain yield and chemical properties of soil were considered in this study. It was found that growers of the area have strong indigenous perceptions for assessment of soil fertility. Higher density, better rice grain yield and chemical properties of soils were found better indicator of soil fertility as per grower's perceptions.

INTRODUCTION

Agriculture in the mid-hill conditions is characterised by the close relationship between crop production, livestock, forestry and fisheries. Forest trees and crops provide fodder and bedding materials for livestock, which provides animal protein and manures. In wetland rice cultivation (*pani kheti*), fertility status is maintained by leaving crop residues in-situ, supplying manures and forest litter wash from the hill slopes (Choudhary *et al.* 2012). Efforts have not been done to maintain or enhance the soil fertility status in mid-hill conditions, however, site-specific soil and water conservation measures are being given paramount importance. There is a limited document available which shows the long-term fertility status of the soil with respect to traditional cropping system and management practices imposed. The adoption level of improved techniques has been limited mainly due to inadequate extension system. Even though extension services are provided to stakeholders, regardless of the size of their farm land, they thought them to be inadequate, because of not meeting their specific requirements (Benjamin 2013).

Farmer's knowledge on soil fertility has been ignored completely, but due to participatory research, it becomes clear that the indigenous knowledge of farmers on soil fertility has a well developed ability. Their knowledge on differentiating fields on same vicinity/farms is fool proof. Farmers use many criteria to judge the soil fertility of their farm, including economic and ethnic influences, to categorize their soils, but weed density, diversity and health of the weeds are main criteria to decide the soil fertility. Growers of the hill ecosystem, assess soil fertility by visualizing the luxuriant growth of *Ageratum conyzoides*. However, the negative effect of *Ageratum conyzoides* had also been reported by researchers that it reduced the crop yield (Kohli *et al.* 2006), yield reduction and high labour inputs in maize (Wezel *et al.* 2000), alternative host of a number of pathogens and nematodes. It also releases some allelochemicals that could inhibit the growth of other species (Dogra *et al.* 2009).

As such, they assess the fertility of the soil using a wide range of indicators which they can see or feel, including crop yields, soil depth, drainage, moisture content, manure requirements, water source, slope, and weed abundance (Desbeiz *et al.* 2004). However, researchers were more focused on a few criteria like soil nutrient status or physical properties of the soil on deciding the soil fertility. In order to know the actual fertility status of the soil and farmer's perceptions and assessment of soil fertility were studied to prove indigenous knowledge on soil fertility judgment by farmers of mid-hill condition of Arunachal Pradesh.

MATERIALS AND METHODS

The study was conducted from 2010 to 2012 in 13 villages of two districts West Siang and Upper Subansiri of Arunachal Pradesh in wet land rice (*pani kheti*). The altitude of the study area varied from 550 to 950 m above mean sea level (with 5-10% of slope). Majority of the household were engaged in rice cultivation during the rainy season. The farming system consists of compartmental bunding with lowland irrigated or partially irrigated leveled field (*pani khet*) and terrace lowland. These lands are owned by villagers and grow rice by own or giving on rent.

A random sampling method was employed to select the sample of farmers from the study area. A total of 78 respondents/farmers were selected from 13 villages at random and enquired their perception on soil fertility status. Six key informants from each village were gathered at the field and as per their perceptions, scores were given. Farmer's perceptions on soil fertility status were ranked from high, medium and low. After interviews, during March- April soil samples were collected from respective fields of 20 cm depth (plough depth). The farmer's judgments of only a few parameters were taken into considerations; those were a) density of *Ageratum conyzoides*, b) soil colour, and c) rice productivity. The details of said parameters which were used for comparison are given in **Table 1**. In the study area, there was not much deviation observed in rice cultivation practice except varietal differences.

The perceptions of 78 respondents were taken into consideration and information was used to assess the fertility status of their fields. Modified farmers' indicators were used as suggested by Desbeiz *et al.* (2004) and classified based on their perceptions: Soil characteristic indicators (soil properties which the farmers felt characterised high, medium or low fertile soils). Crop performance indicators (crop characteristics mainly yield reflecting soil fertility status). Biological indicators (density of *Ageratum conyzoides* reflected soil fertility status).

Decision/assessment	Indicators used
What is the current soil fertility?	Soil colour, crop yield, weeds
What potential does this field have?	Water retention ability, crop yield, weeds
Is the soil management strategy in this field working?	Soil colour, crop yield, weeds
How is the current crop performing?	Crop yield, weed growth

For the analysis of soil chemical properties, soil pH was determined by a pH meter after extraction from a 1: 2.5 ratios of soil and water. Organic carbon (OC) was estimated using the Walkley and Black dichromate method, and available nitrogen (N) using the standard micro-digestion method (Kjeldahl). For available phosphorus (P_2O_5) determination, the Bray and Kurtz method (0.03M NH_4F/0.1M HCl extraction) was used. Exchangeable potassium (K_2O) was estimated by 1M ammonium acetate extraction followed by flame photometric determination. The N, P_2O_5 and K_2O status was compared from **Table 1**. The different parameters of the studies were analyzed using SAS Version 9.3 (SAS Institute Inc., Carry NC USA).

RESULTS AND DISCUSSION

Socio-economic status

The demographic, socio-economic and land characteristics of the farmers interviewed are presented in **Table 2**. The majority of the respondents were male (88.5%), with an average age of 42.5 years, and had the cropping experience of 19 years. The main source of the income (84.6%) was sold by farm produce. Crops were only grown during the rainy season and kept the land fallow throughout the year. During the period, weed flora was allowed to grow and later incorporated into the soil in the month of April. Simultaneously, the second flush of weeds was also allowed to grow and again incorporated at the end of May. Later, the fields were inundated with water. However, few of the farmers also go for third turning just before transplanting. In the rainy season, fields were irrigated through locally developed irrigation channels. These channels were diverted from nearest tributaries well ahead of the field (1-2 km ahead) and channeled to their field. Once water enters into the cropping area, it passed as per slope of the field and excess water drains out from another end of the field.

Soil fertility indicators

Among the different characteristics, respondents were asked to rank the principal indicators most appropriate deciding soil fertility status, the majority were cited crop yield (96%), followed by soil colour (93%) and weed growth (90%). However, some of the farmers also ranked water availability (68%) in the field. Therefore, overall there was a strong accord between the farmers' assessment of fertility status of the soil and the indicators that they had said in the interviews, which they were used to assess soil fertility. There was, however, considerable variation between individual farmers in the indicators used. It became

Table 1. Criteria for classification of weed density, soil fertility and rice grain yield

Particular	Soil colour	*Ageratum conyzoides* density (no./m^2)	N	P_2O_5 kg/ha	K_2O	Rice yield (t/ha)
Low	Yellowish brown	<25	<280	<10	<270	<1.5
Medium	Brown	25-50	280-400	10-15	270-350	1.5-3.0
High	Dark brown to black	>50	>400	>15	>350	>3.0

Table 2. Demographic and socio-economic characteristics of the sampled farmers in thirteen villages with two districts in the Arunachal Pradesh

Variables	Respondents (n=78)
Farmers gender (%)	
Females	11.5
Males	88.5
The average age of respondents (years)	42.5
Farmer's education (%)	
Higher Secondary	9.2
High School	14.1
Middle School	18.0
Primary School	25.5
None	33.2
Average family size	5.5
The main source of income (%)	
Agriculture (sale of farm produce)	84.6
Government servant	11.5
Business	3.9
Cropping experience (years)	19.0
Average farm size (ha)	
Wetland	1.2
Upland	1.5

clear from the discussions that farmers use soil fertility indicators to assess soil fertility and make soil management decisions. However, farmers of the area use more than one indicator to decide or assess the soil fertility status. Some of the respondents use number of criteria to decide, but in the study, factors were pre-decided as per the perceptions of large group voice. The overall pattern of judging the soil fertility of 13 villages was the same. Farmers of the area hardly supply inputs into the soil, therefore, indigenous knowledge on measuring soil fertility status play a crucial role to better crop harvest.

Rice grain yield and weed density

Respondent has given the ranking of soil fertility by seeing the weed coverage. These were counted and categorized, and found that the *Ageratum conyzoides* density into high fertile soils was >50 plants/m^2, and medium fertile soils had 25-50 plants/m^2, whereas, low fertile soils had <25 plants/m^2. Rice grain and *A. conyzoides* density were highest in black to brown coloured soil (3.0-3.5 t/ha and 40-72 no./m^2, respectively) followed by brown soil (1.5-2.9 t/ha and 31-63 no./m^2, respectively). However, the lowest rice grain yield and *A. conyzoides* density were measured in yellowish to brown soil (0.9-1.4 t/ha and 11-31 no./m^2, respectively). It was also noticed a few outliers in yellowish to brown coloured soil. The average rice grain yield and density of *A. conyzoides* were noticed with 2.41 t/ha and 38.8 no./m^2, respectively (**Table 3**).

Rice grain yield followed the linear relationship with weed density and soil moisture content with a coefficient of determination of 0.77 and 0.81, respectively (**Figure 1a and b**). These clearly showed that there was a positive association between rice grain yield with weed density and soil moisture content. Soil moisture content was more linear with the positive association and this gave the better association with rice yield. The overall moisture content of the soils was recorded with 23.7% (**Table 3**). A similar finding was also corroborated by Choudhary (2017).

Table 3. Weed density, chemical properties of the soil and rice yield in the study area (n=78)

Particular	Mean	Low	Medium	High
		% respondent		
Weed density (no./m^2)	38.8±12.25	17.9	46.2	35.9
Soil moisture content (%)	23.7±3.22	53.8	28.2	17.9
pH	5.44±0.26	-	-	-
Available N (kg/ha)	284.2±80.18	18.0	41.0	41.0
Available P_2O_5 (kg/ha)	10.9±2.18	17.9	42.3	29.7
Available K_2O (kg/ha)	314.0±49.13	23.1	35.9	41.0
Crop yield (t/ha)	2.41±0.72	16.7	55.1	28.2

SD: standard deviation (±)

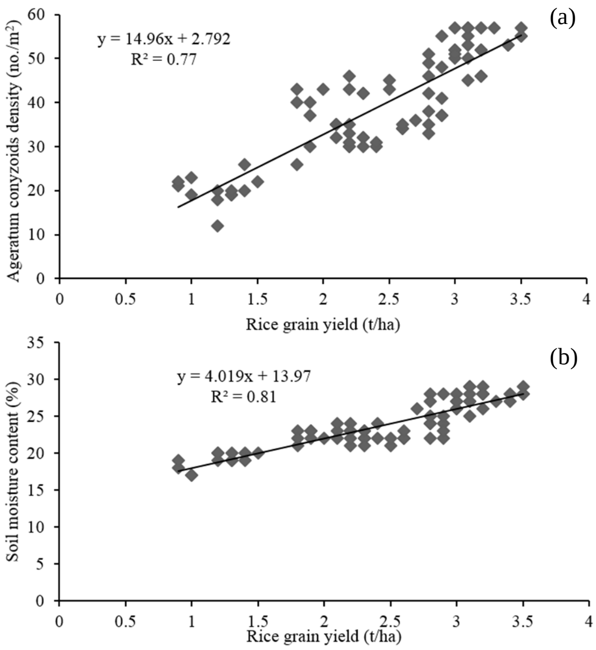

Figure 1. The relationship between rice grain yield and a) *A. conyzoids* density/m^2, and b) soil moisture content (%)

It was recorded that among the soil colour rank assigned, black to deep brown and brown colour comes under high fertile soil. Whilst, in medium fertile soils all three-group black to deep brown, brown and yellowish brown soil colour was noticed, and low fertile soils have only yellowish brown coloured soil.

Nutrient status of soil

The results of chemical analysis of the sampled fields are shown in **Table 3**. The pH of most of the soil varied from 5.0-5.8 indicating acidic in nature corresponding to another mid hill area (Choudhary and Kumar 2015). The average pH of the soils was recorded of 5.44. Nitrogen levels were medium in range (284.2 kg/ha), average available P_2O_5 was recorded of low levels with 10.9 kg/ha and available K_2O was estimated intermediate to a high level (314.0 kg/ha). It was measured that productive soils have more of available N, P_2O_5 and K_2O and *vice-versa* with low productive soil. There was a strong correspondence between the farmer's assessment of soil fertility and the measured soil chemical characteristics. Respondents described as high fertile soils were found on higher values of available N, P_2O_5 and K_2O, and considerably higher soil pH. However, the majority of the factors are interrelated, hence, these were not independent.

Similar to rice grain yield, weed density was correlated with chemical parameters, weed density has followed the positive linear relationship with soil pH with R^2=0.73, available N, R^2=0.79, available P_2O_5, R^2=0.76 and available K_2O, R^2=0.61 (**Figure 2a, b, c** and **d,** respectively). Inference can be drawn from **Figure 2** that near the neutral pH, there was better availability of soil nutrient and more the weed density.

In a large chunk of the area, low soil fertility is a major hindrance in crop production. However, it's not a universal problem and some other factors may also responsible for lesser crop production. Weeds, compete with the crop for various resources if both were growing together, but, if weeds are alone in the field then there is no question of competition, the majority of plant nutrients are being taken up by weeds and with incorporation, nutrients were returned into the soils (Roder *et al.* 1995). It was also noticed that *Ageratum conyzoides* has strong and deep root system which may mine the nutrients from the deeper soil.

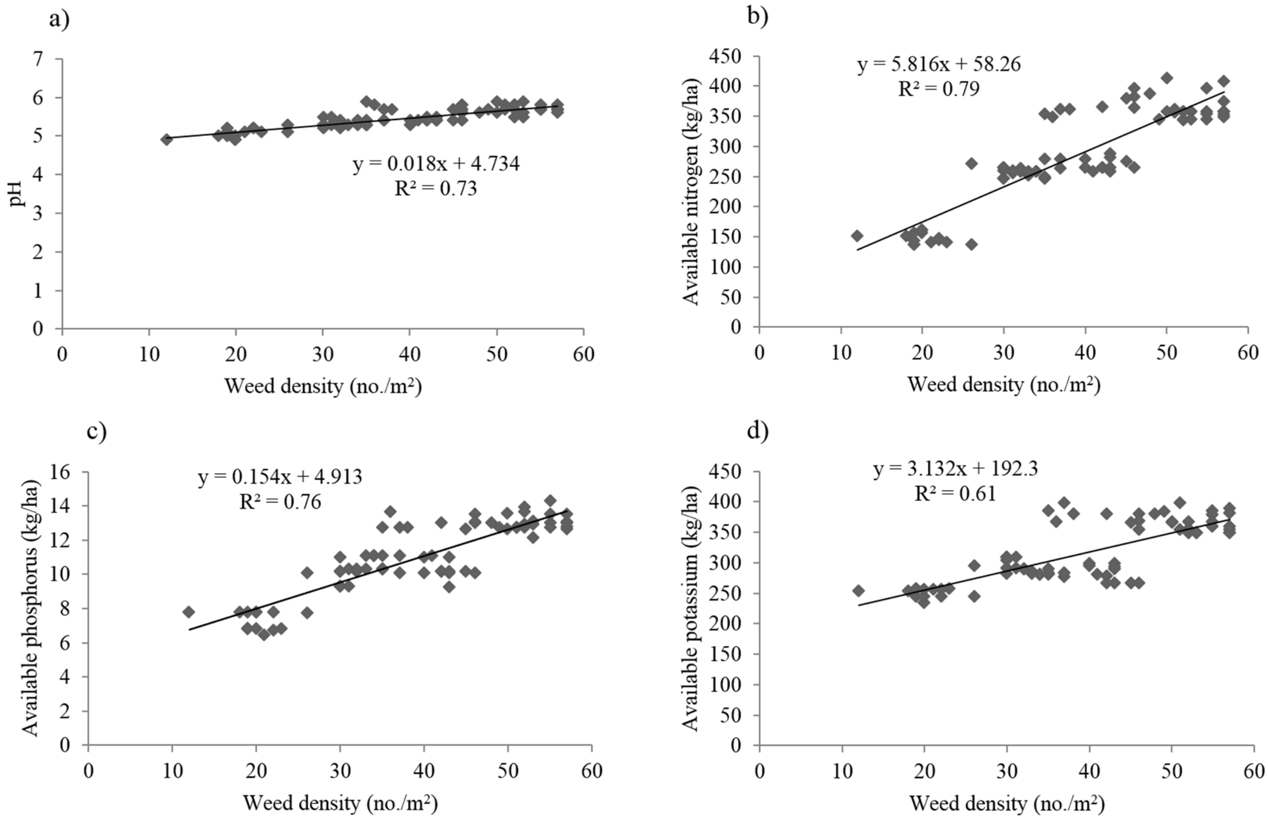

Figure 2. Relationship between density of weeds (*Ageratum conyzoides*) and chemical properties of soil a) pH, b) available nitrogen, c) available phosphorus and d) available potassium

The biomass of the fallow vegetation generally represents the major pool for N, P, K, Ca and Mg (Andriesse and Schelhaas 1987). Removal of vegetation had irreversible loss of nutrients, whereas incorporation certainly increases the availability. Trehan *et al.* (2008) reported that the response of crop residues was visible only after second year onwards. Incorporation of residues increased the NPK use efficiency by 14 and 15% in potato and by 22 and 27% in onion during second and third years, respectively.

Desbeiz *et al.* (2004) have reported that *Ageratum conyzoides, A. houstonianum,* and *Galinsoga parviflora* were important weed species which predominantly grow in fertile soil. Fertile soils have more of plants from compositeae family and less fertile soils have more plants from poaceae family *(Digitaria sanguinalis, Imperata cylendrica* and *Cynodon dactylon)*.

The correlation coefficient in **Table 4** depicts the degree of association between two variables. The study demonstrated that yield with six independent variables with 78 observations had shown a positive correlation with each other. The correlation coefficient of the majority of the parameters was significant at 1% level of significance. However, soil moisture has shown significant at 5% level of significance with weed density, whereas potassium has non-significant with weed density at a tested level of significance.

The findings confirmed the indigenous knowledge of farmers that higher density of *Ageratum conyzoides* results in higher rice grain yield and improved soil fertility.

Table 4.Correlation of different variables with respect to yield

Particulars	Weed density	Soil moisture	pH	Nitrogen	Phosphorus	Potassium
Weed density	1.00					
Soil moisture	0.27*	1.00				
pH	0.41**	0.34**	1.00			
Nitrogen	0.43**	0.61**	0.60**	1.00		
Phosphorus	0.29**	0.42**	0.56**	0.71**	1.00	
Potassium	0.21	0.52**	0.62**	0.73**	0.66**	1.00

*Significant at 5%; **significant at 1%

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