The Pharma Innovation Journal 2023; 12(10): 811-817

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 811-817

www.thepharmajournal.com
Received: 14-08-2023
Accepted: 23-09-2023

Anil Kumar Kori
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

KK Jain
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Ajay Kumar shah
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Atul Singh
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Anil Kumar Kori
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Correlation and regression studies of yield attributing variables with chickpea seed yield under *Jatropha* based agroforestry

Anil Kumar Kori, KK Jain, Ajay Kumar shah and Atul Singh

Abstract

In an 8 to 9 year old *Jatropha curcas* plantation, planted at a distance of 3x3m, the study was started to determine the growth characteristics of the chickpea (gram) crop under the *Jatropha curcas* based Agroforestry system over the years 2019-20 and 2020-21. The correlation coefficient between various growth characteristics on gram crop yield significant positive association with Seeds per plant (0.929, 0.812 and 0.880), Plant height (0.807, 0.793 and 0.830), Plant population (0.765, 0.821 and 0.828), Root nodule (0.763, 0.915 and 0.881), and Pods per plant (0.760, 0.832 and 0.821) over the course of both the years and on a pooled basis. Seeds per plant, plant height, plant population, root nodule, and pods per plant all demonstrated a positive and substantial correlation throughout both the years and on a combined basis. The regression analysis revealed that the linear increase in yield attributing parameters was predicted with Plant population (1.390, 1.929 and 1.760), Plant height (0.433, 0.806 and 0.601), No. of branches (6.222, 7.391 and 8.28), Root length (0.476, 2.681 and 2.486), Root nodule (0.668, 0.261 and 0.840), Pods per plant (0.127, 0.187 and 0.158) and Seeds per plant (0.240, 0.286 and 0.263) during both years and on pooled basis. With an increase of one unit for each parameter, yield gains may be anticipated. The most crucial factors in predicting yield are plant population, number of branches, pods per plant, and seeds per plant. The coefficient of determination (R2) value for seeds per plant (0.863, 0.659 and 0.774), plant height (0.652, 0.628 and 0.688) and plant population (0.585, 0.673 and 0.685), followed by root nodules (0.583, 0.058 and 0.775) pods per plant (0.578, 0.693 and 0.672), number of branches (0.452, 0.786 and 0.813) and root length (0.040, 0.570 and 0.492) both in years and on a pooled basis.

Keywords: *Jatropha curcas,* correlation, regression, growth characters, chickpea (gram), and yield

Introduction

Agroforestry is an ideal option to increase land productivity, increase outside forest cover, and reduce human pressure on forests in various agro ecological regions. It is also a viable option for preventing and mitigating change. Agroforestry is one of the alternatives for sustainable management of natural resources. A land use system that integrates trees or perennials, crops and animals, it has been practiced by farmers for centuries. The goal of Agroforestry systems is to increase, diversify and sustain production of economic, environmental and social benefits. Agroforestry practices are considered the most important and potential agricultural system to minimize land degradation. It improves soil fertility, reduces erosion and weed infestation, improves water quality, increases biodiversity, enhances aesthetics and sequesters carbon. Agroforestry always remains productive for the farmer and generates continuous income. Given the shrinking per capita land availability, the Agroforestry system with the integration of perennial woody plants is the most suitable technology to increase the overall productivity of food, feed and fuel, thereby reducing the risk of weed infestation in agriculture. There are many innovative farmers who have developed Agroforestry systems or modified existing ones to adapt them to local conditions. Tree Born Oil Seeds (TBO) fit into most of these systems and contribute positively to overall productivity and farm income. Initial programs were based mainly on large-scale plantations of *Jatropha* (*Jatropha curcas*) on fallow land, but seed yields proved to be limited and highly variable under low input conditions, leading to economic unavailability and limited production potential (Achten *et al*., 2014; van Eijck *et al*., 2014) [1, 17]. Chickpeas (*Cicer arietinum* L.) are one of the oldest and most widely cultivated legumes in India. In our country, it is mainly grown in the states of Madhya Pradesh, Maharashtra, Andhra Pradesh, Rajasthan and Odisha. India is the largest producer of chickpeas, accounting for 75% of world production.

Because chickpeas have slow early growth and a small stature, they are very susceptible to weed competition and often significant losses can occur if the weeds are not controlled in a timely manner. Weed competition with chickpea becomes more important as the crop is sown in the post-rainy season under rainfed and dryland conditions and hence timely and effective weed control is required. Weeds compete strongly with crops for nutrients, moisture, light and space and lead to yield losses of up to 75% in chickpeas (Chaudhary *et al*., 2005) [4]. Herbicides are plant protection products that are used in high-input agriculture to kill unwanted weeds and thus prevent yield losses caused by these harmful plants (Cork and Krueger, 1992) [5]. In order to achieve a higher yield, it is important to control weeds in a timely manner using appropriate methods. Due to the ease and lack of manpower for weed control, especially in the critical period, the use of herbicides is widespread. There are more than 75 species of weeds that infest chickpea fields. These species are mostly dicotyledonous and belong to 26 different families (El-Brahli, 1988) [7]. It contributes around 24% of total grain production. As a high consumption staple crop, any increase in growth character could have a significant impact on human consumption around the world. Taking into account the above facts, the present investigation was carried out. Many of the correlation and path analysis studies have been conducted in crops. Correlation coefficients between yield and yield components as well as direct and indirect effects of various plant traits on yield and yield components were reported by Noor *et al*. (2003) [12]; Arshad *et al*. (2004) [2];Atta *et al*. (2008) [3]; Padmavathi *et al*. (2013) [13].

Materials and Methods

The study was initiated to find out the relationship between growth characteristics of Gram plants under *Jatropha curcas* based Agroforestry system in 2019-20 in an 8-year-old *Jatropha* plantation planted at a distance of 3m x 3m. The soil of the test field had a clayey texture and an almost neutral reaction. The nitrogen, phosphorus and potash available in the soil were 288 (medium), 20 (medium) and 170 (very low) kg/ha, respectively. Jabalpur is located at 23.3°N latitude and 79.5°E longitude with an elevation of 411.78 m above mean sea level. It belongs to the Kymore Plateau and Satpura Hills agro-climatic regions and is popularly known as the rice-wheat growing zone of Madhya Pradesh. The region's climate is subtropical with hot, dry summers and cold, dry winters. The average annual rainfall in Jabalpur is 1250 to 1400 mm. Rainfall occurs mainly between mid-June and September, with occasional rains in winter. The average monthly temperature reaches up to 45 °C in summer. In order to measure the direct influence of one variable on another and to allow the division of the correlation coefficient into a component of the direct effect of a predictor variable on its response variable and indirect effects of a predictor variable in the integrated structure of the plant, the overall correlation between the different variables was observed due to the long lifespan of trees, a function of the direct and indirect relationship between various variables. Analysis of growth traits is a very important aspect of variation and selection studies. This correlation and regression study provides insight into a complex relationship between different growth traits in a biological system. With advances in computer programming, multivariate techniques are increasingly being used in the analysis of biological data. It is necessary to have a linear relationship between the different growth traits and quantified information on how the growth traits affect yield.

The correlation matrix between various growth characteristics of crops and trees as well as wheat yield and tree stand biomass was calculated according to the suggestions of Sendecor and Cochran (1967) [14] with the following formula.

$$\text{Correlation coefficient}(r) = \frac{\sum xy - \frac{(\sum x)\ x\ (\sum y)}{N}}{\sqrt{\frac{\sum y^2 - (\sum y)^2}{n} \cdot \frac{\sum x^2 - (\sum x)^2}{n}}}$$

Where,
r: Correlation
$\sum X$: add up all the X scores
$\sum Y$: add up all the Y scores
$\sum X^2$: square each X scores and then add them up
$\sum Y^2$: square each Y scores and then add them up
$\sum XY$: multiply each X score by its associated Y score and then add the resulting products
n: number of Pairs of data

In order to predict the effects of weeds on yield of gram crop regression models were used and coefficient was correlated to interpret quantitative change in yield. The following regression equation was used

$$\hat{Y} = a + bx$$

Where, $\hat{Y}$ = yield
X = variables
a and b are regression constant and regression coefficient, respectively.

Results and discussion

Correlation

The data and results presented in Table 1 showed that the correlation coefficients in the first year (2019-20) between various yield determining parameters and seed yield showed that seeds per plant had the highest positive correlation (0.929) between various yield determining parameters, followed by LAI (863). Plant height (0.807), plant population (0.765), root nodules (0.763) and pods per plant (0.760). In the second year (2020-21), the various yield attributing parameters with seed yield showed that root nodule had the highest positive correlation (0.915) between the various yield attributing parameters, followed by number of branches (0.886), pods per plant (0.832) and the plant population (0.821) and seeds per plant (0.812). The pooled mean of two years (2019-20 and 2020-21) revealed that number of branches had the highest (0.903) positive correlation with seed yield under different yield parameters followed by root nodules (0.881), seeds per plant (0.880), Plant height (0.830), plant population (0.828) and pods per plant (0.821) under gram *Jatropha* based Agroforestry system. A high positive correlation between the number of pods per plant and seed yield can be attributed to increased sink resistance (Nakaseko, 1984) [11]. Diaz Carrasco *et al*. (1985) [6] also suggested that yield could be increased by selection for earliness, height and more pods per plant, which is evident in the present study. Among yield-determining traits, plant height showed a positive and significant correlation with biomass, suggesting that increased plant height is associated with higher production of biomass. The number of pods per plant showed a significant positive association with plant height. The positive direct effect of the number of pods per plant on seed yield is also consistent with previous reports (Jatasra *et al*., 1978; Padmavathi *et al*., 2013) [9, 13].

Table 1: Correlation coefficient between yield attributing parameters with seed yield (q ha^{-1})

Character	**Plant height**	**No. of branches**	**Root Length**	**Root Nodule**	**pods per plant**	**seeds per plant**	**LAI**	**Seed yield q ha^{-1}**
	X_2	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**	**Y**
2019-20								
X_1-Plant population	0.714**	0.639*	0.599*	0.573	0.859**	0.779**	0.722**	0.765**
X_2-Plant height	-	0.560	0.171	0.612*	0.808**	0.841**	0.675*	0.807**
X_3-No. Of branches	-	-	0.478	0.709**	0.738**	0.599*	0.669*	0.674*
X_4-Root length	-	-	-	0.332	0.639*	0.187	0.434	0.302
X_5-Root nodule	-	-	-	-	0.586*	0.688*	0.865**	0.763**
X_6-Pods per plant	-	-	-	-	-	0.688*	0.727**	0.760**
X_7-Seeds per plant	-	-	-	-	-	-	0.699*	0.929**
X_8-LAI	-	-	-	-	-	-	-	0.863**
2020-21								
Character	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y
X_1-Plant population	0.716**	0.742**	0.756**	0.743**	0.789**	0.827**	0.342	0.821**
X_2-Plant height	-	0.815**	0.897**	0.673*	0.759**	0.832**	0.078	0.793**
X_3-No. Of branches	-	-	0.721**	0.826**	0.719**	0.872**	0.288	0.886**
X_4-Root length	-	-	-	0.688*	0.780**	0.795**	0.133	0.755**
X_5-Root nodule	-	-	-	-	0.746**	0.679*	0.513	0.915**
X_6-Pods per plant	-	-	-	-	-	0.673*	0.604*	0.832**
X_7-Seeds per plant	-	-	-	-	-	-	0.086	0.812**
X_8-LAI	-	-	-	-	-	-	-	0.356
Pooled								
Character	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y
X_1-Plant population	0.761**	0.778**	0.844**	0.723**	0.862**	0.835**	0.566	0.828**
X_2-Plant height	-	0.784**	0.611*	0.698*	0.790**	0.841**	0.318	0.830**
X_3-No. Of branches	-	-	0.658*	0.838**	0.800**	0.823**	0.533	0.903**
X_4-Root length	-	-	-	0.701*	0.881**	0.585*	0.618*	0.702*
X_5-Root nodule	-	-	-	-	0.701*	0.713**	0.604*	0.881**
X_6-Pods per plant	-	-	-	-	-	0.682*	0.718**	0.821**
X_7-Seeds per plant	-	-	-	-	-	-	0.296	0.880**
X_8-LAI	-	-	-	-	-	-	-	0.559

Note: * -sign indicate significant at 0.05 level of significance.
** -sign indicate significant at 0.01 level of significance.

Regression

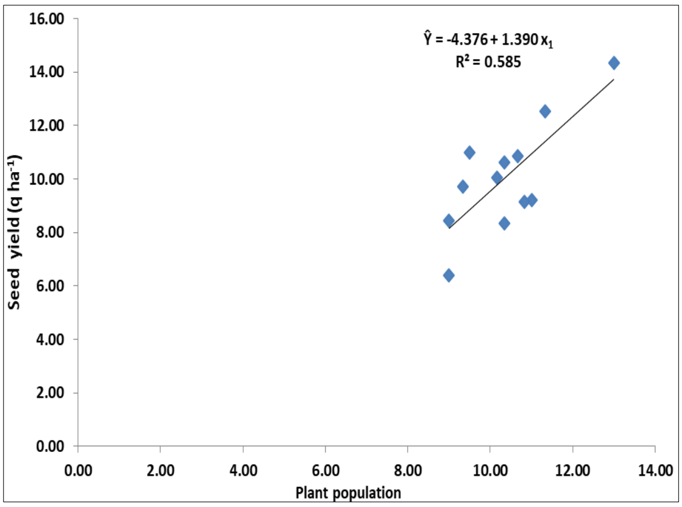
The regression analysis data (Table 2 and Figure 1, 2, 3) revealed that among the various yield determining parameters, the linear increase in yield was predicted with LAI, number of branches, plant population, root nodules, root length and plant height in both years. The yield increases could be predicted for both years (2019-20 and 2020-21) by 29.27 and 6.933, 6.222 and 7.391, 1.390 and 1.929, 0.668 and 0.261, 0.476 and 2.681, 0.433 and 806.

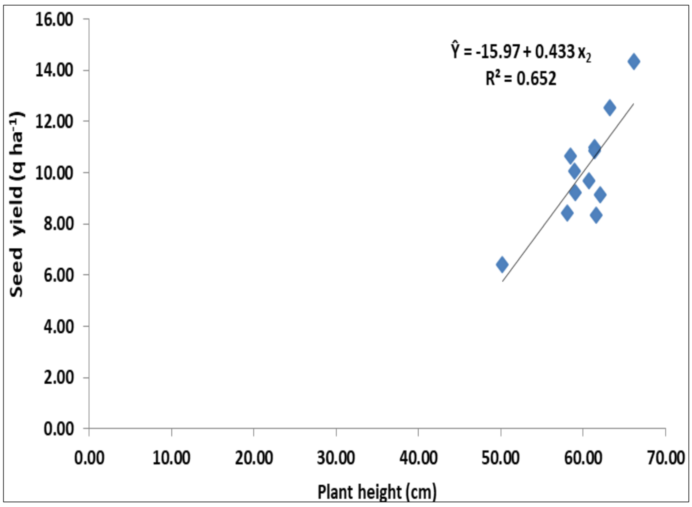
Pooled mean of two years (2019-20 and 2020-21), regression analysis revealed that the linear increase in yield was predicted using LAI, number of branches, root length, plant population, root nodules and plant height. The yield increase could be predicted by 14.40, 8.28, 2.486, 1.760, 0.840 and 0.601 grams of *Jatropha* based Agroforestry system. The similar finding was also reported by Jain and Sharma (2011) [8] Singh *et al*. (2014) [15], Tadesse *et al*. (2016) [16] and Kumar *et al*. (2019) [10].

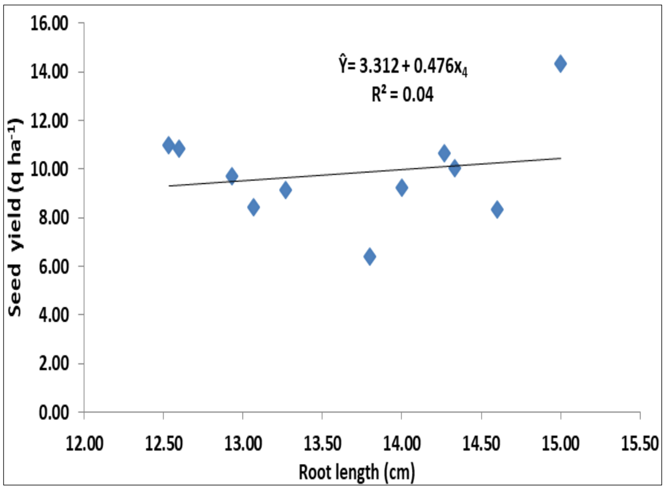
Table 2: Regression between yield attributing parameters with seed yield (q ha^{-1})

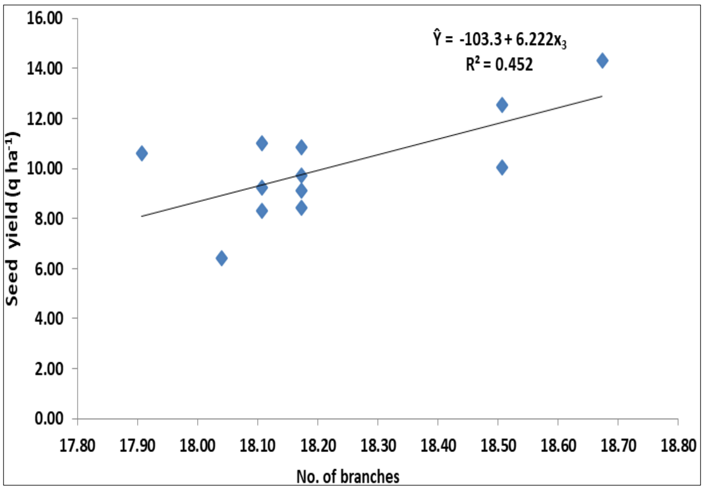
Character	**$\hat{Y}$= a + bx**	**Coefficient of determination (R^2)**
2019-20		
X_1-Plant population	$\hat{Y}$ = - 4.376 + 1.390 x_1	0.585
X_2-Plant height	$\hat{Y}$ = - 15.97 + 0.433 x_2	0.652
X_3-No. Of branches	$\hat{Y}$ = - 103.3 + 6.222 x_3	0.452
X_4-Root length	$\hat{Y}$ = 3.312 + 0.476 x_4	0.040
X_5-Root nodule	$\hat{Y}$ = 0.377 + 0.668 x_5	0.583
X_6-Pods per plant	$\hat{Y}$ = 5.975 + 0.127 x_6	0.578
X_7-Seeds per plant	$\hat{Y}$ = 1.856 + 0.240 x_7	0.863
X_8-LAI	$\hat{Y}$ = -100.1 + 29.27 x_8	0.734
2020-21		
X_1-Plant population	$\hat{Y}$ = - 8.835 + 1.929 x_1	0.673
X_2-Plant height	$\hat{Y}$ = -36.26 + 0.806 x_2	0.628
X_3-No. Of branches	$\hat{Y}$ = -144.8 + 7.391 x_3	0.786
X_4-Root length	$\hat{Y}$ = -27.42 + 2.681 x_4	0.570
X_5-Root nodule	$\hat{Y}$ = 9.010 + 0.261 x_5	0.058
X_6-Pods per plant	$\hat{Y}$ = 4.243 + 0.187 x_6	0.693
X_7-Seeds per plant	$\hat{Y}$ = -1.157 + 0.286 x_7	0.659
X_8-LAI	$\hat{Y}$ = -13.81 + 6.933 x_8	0.133

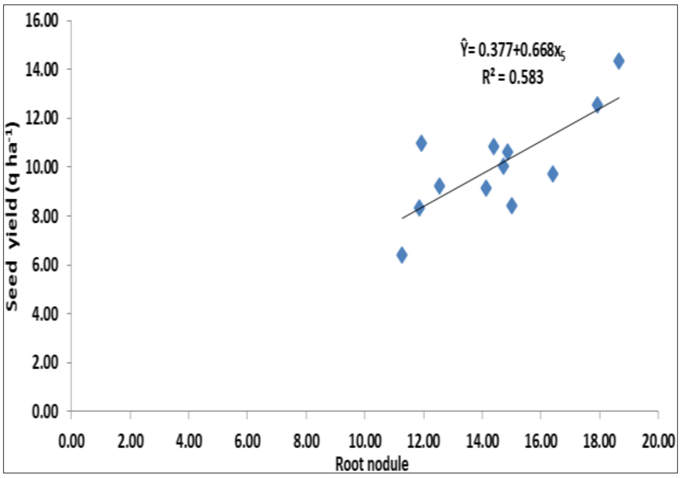
	Pooled	
X_1-Plant population	$\hat{Y}$ = -7.625 + 1.760 x1	0.685
X_2-Plant height	$\hat{Y}$ = - 25.07 + 0.601 x_2	0.688
X_3-No. Of branches	$\hat{Y}$ = - 152.2 + 8.28 x_3	0.813
X_4-Root length	$\hat{Y}$ = - 24.36 + 2.486 x_4	0.492
X_5-Root nodule	$\hat{Y}$ = - 1.368 + 0.840 x_5	0.775
X_6-Pods per plant	$\hat{Y}$ = 5.199 + 0.158 x_6	0.672
X_7-Seeds per plant	$\hat{Y}$ = 0.474 + 0.263 x_7	0.774
X_8-LAI	$\hat{Y}$ = - 42.76 + 14.40 x_8	0.313

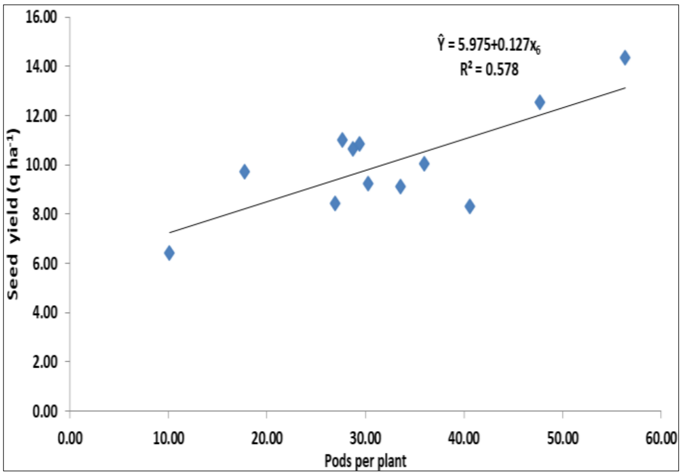












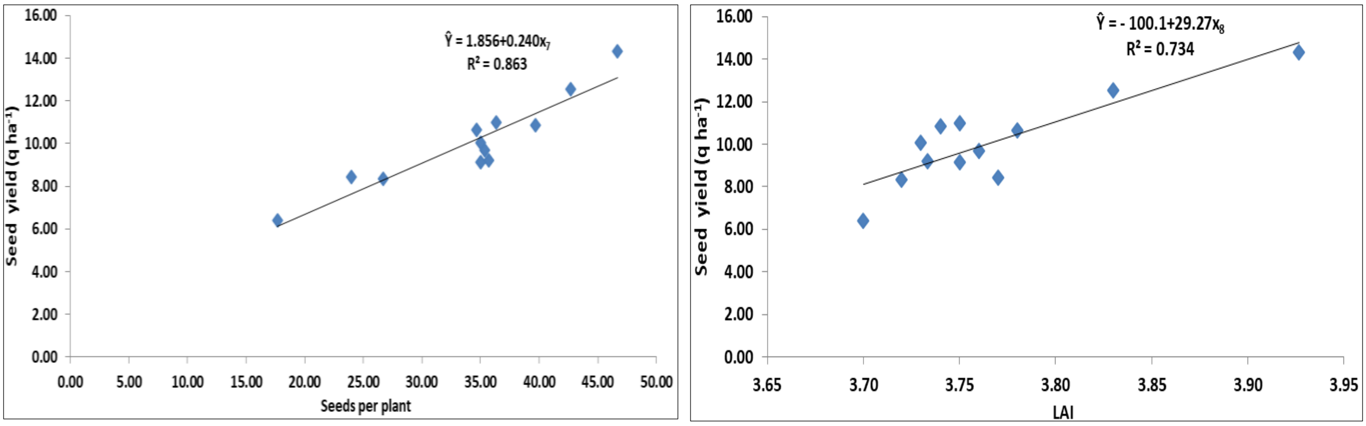
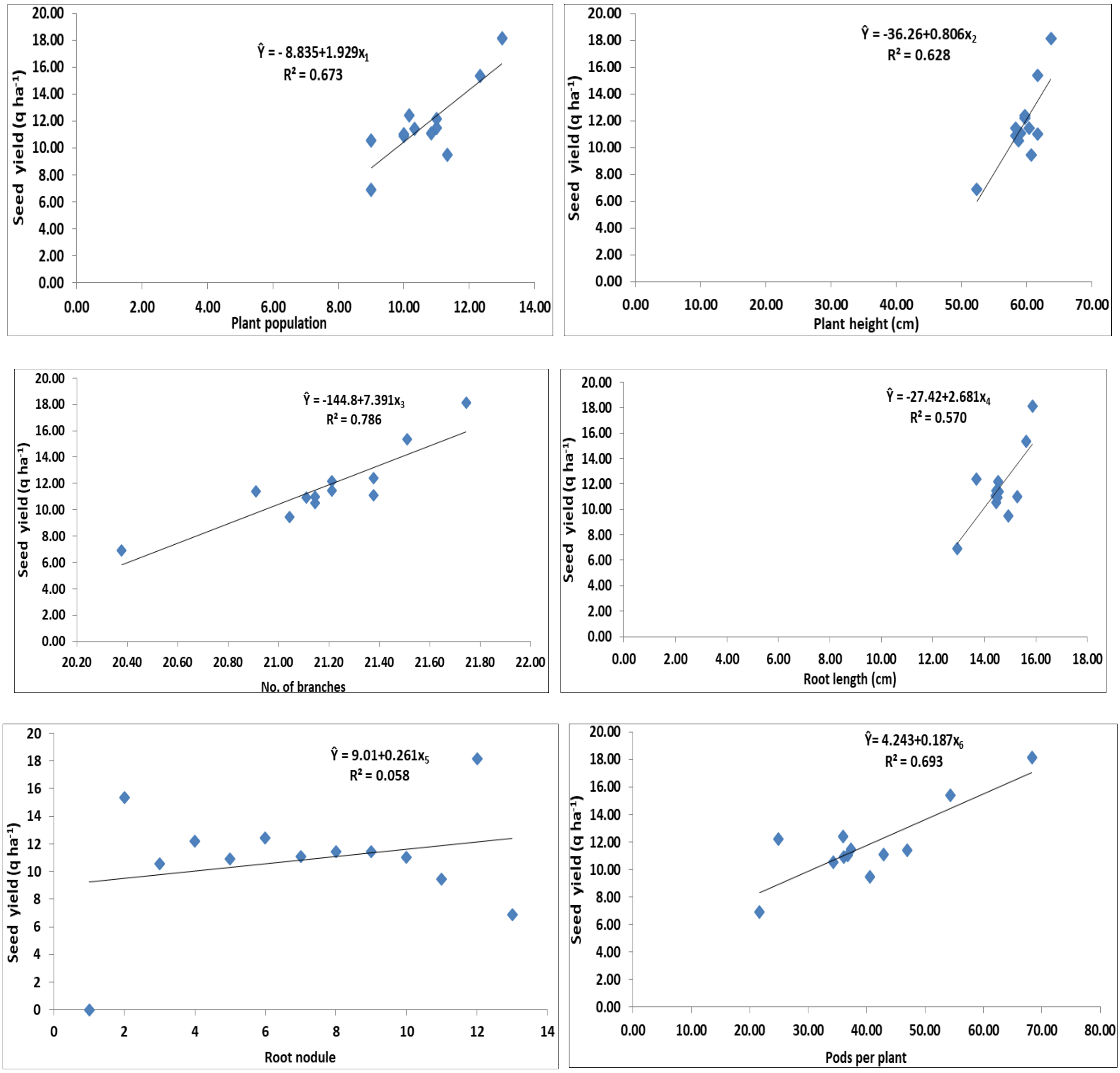


Fig 1: Regression of yield attributing parameters on seed yield (q ha^{-1}) during first year (2019-20)



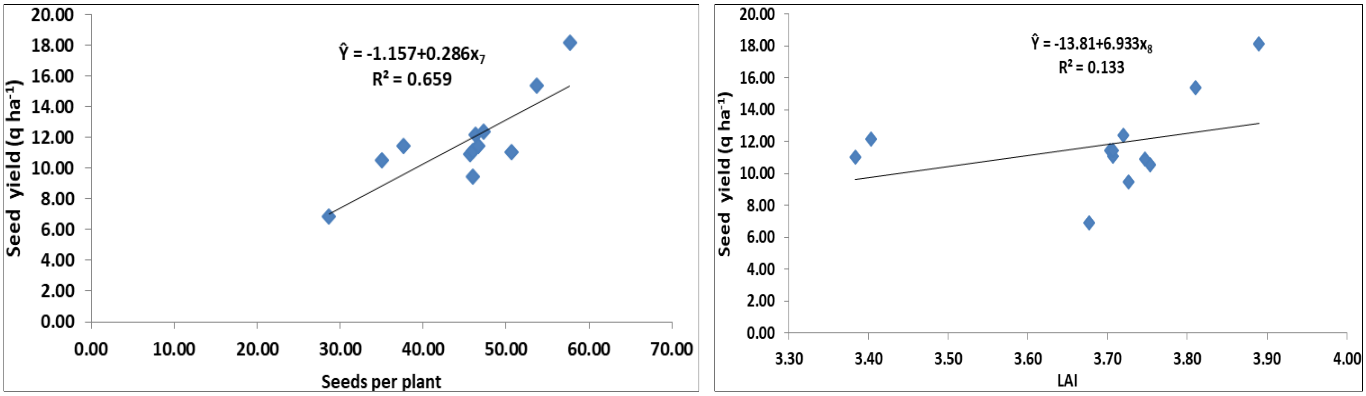
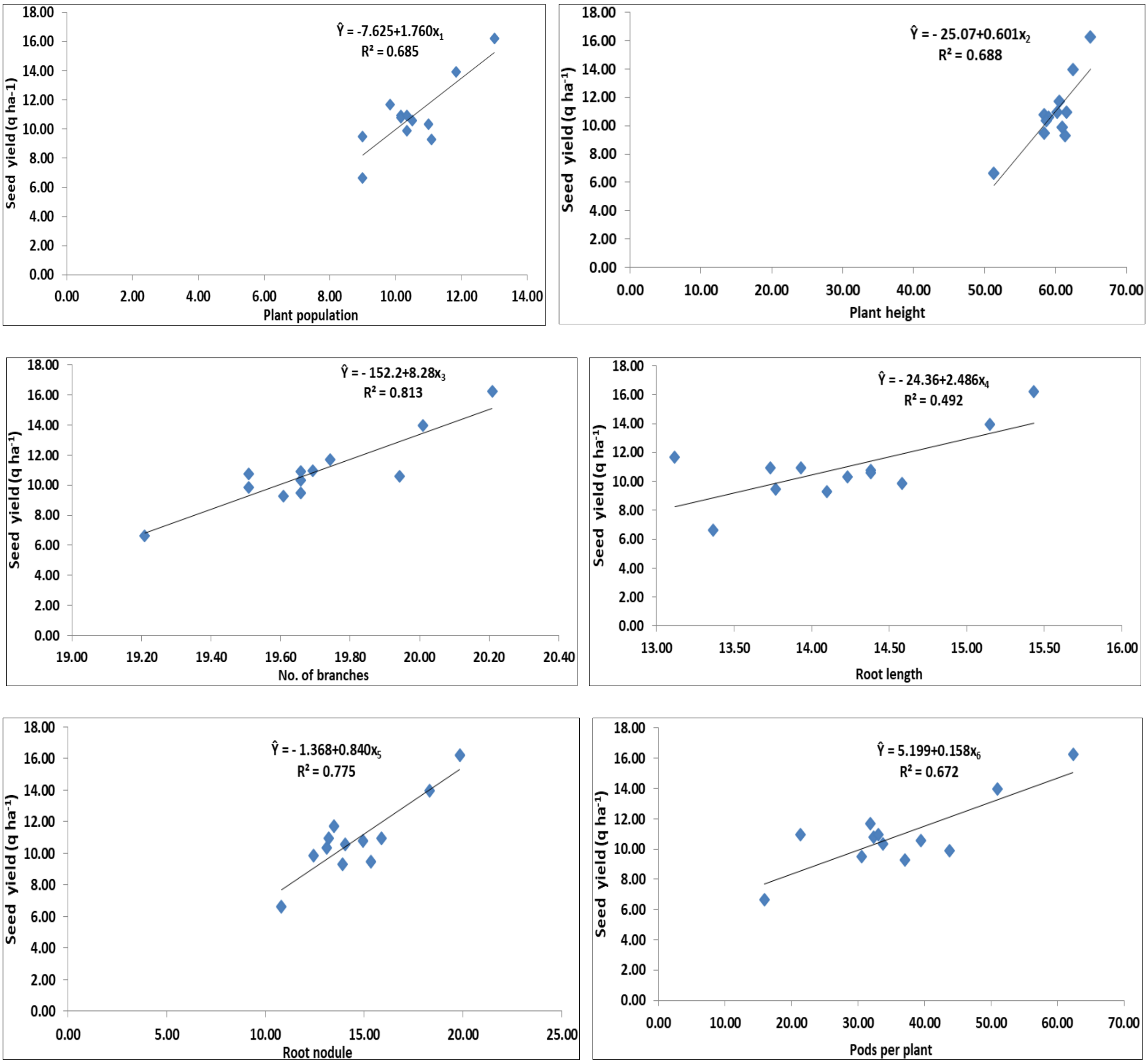


Fig 2: Regression of yield attributing parameters on seed yield (q ha [1]) during second year (2020-21)



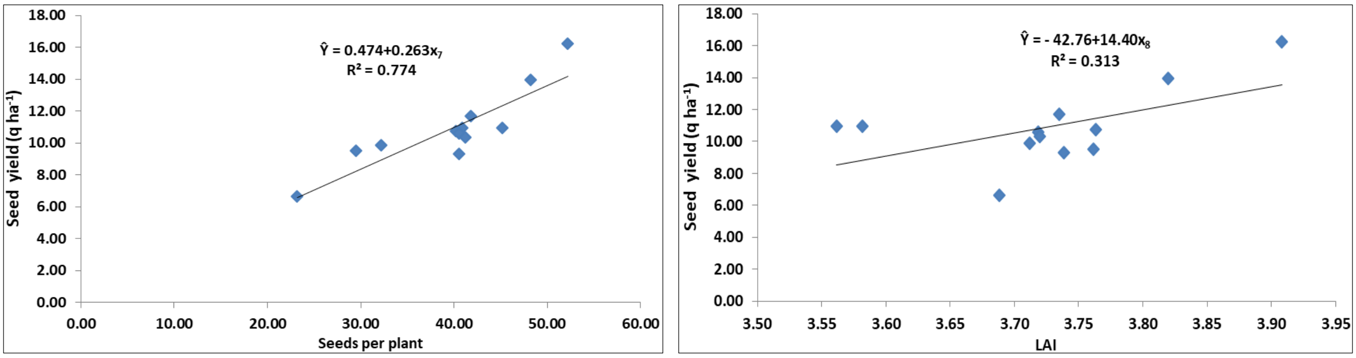


Fig 3: Pooled regressions of yield attributing parameters on seed yield (q ha^{-1})

Conclusion

Under chickpea, *Jatropha* based Agroforestry system found that the factors that most influence seed output are plant population, plant height, number of branches, pods per plant, and seeds per plant. When choosing for high yield, features like Plant population, Plant height, Number of branches, Pods per plant, and Seeds per plant should all be taken into account because they have a significant indirect impact on seed output. Direct selection for this trait might be successful for selecting for maximum output of chickpea, according to a relatively significant positive correlation between the maximum beneficial effects of Seeds per plant, Pods per plant, and Plant Population on seed yield. In regression analysis growth traits of gram, significant traits such as plant height (cm), number of branches, pods per plant and seeds per plant were important and significant and positive for the yield of chickpea crop.

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