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Effect of crop geometry with different levels of phosphorous on growth & yield of green gram (*Vigna radiata* L.) under Jatropha based Agroforestry system

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Abstract
A field experiment was conducted during kharif season (2017) to study the "Effect of crop geometry with different levels of phosphorous on growth & yield of green gram (*Vigna radiata* L.) under Jatropha based Agroforestry system." at the research farm of College of Forestry, Sam Higgin bottom University of Agriculture, Technology and Sciences, Allahabad - 211007 (U.P.), Experiment laid out in randomized block design with three levels of Cropping geometry [30×10 cm, 30×15 cm and 30×20 cm] and three levels of Phosphorus [(20kg ha^{-1}), (40kg ha^{-1}) and (60kg ha^{-1})]. The result shows that application of different levels combination of crop geometry with different levels of phosphorous fertilizers increased growth and yield of green gram. It was recorded from the application of phosphorous fertilizer in treatment T_9 [30x20 +60 kg P/ha^{-1}] increased Pre-harvest observation viz., Plant height, No. of trifoliate leaves per plant, No. of branches per plant, increased. It was also concluded from trail that the application of fertilizers in treatment T_9 [30x20 +60 kg P/ha^{-1}] was found in increasing post- harvest observations viz., No. of Pods per plant, Number of grains per pod, Test weight (g) and grain yield (q/ha), stover yield (q/ha),harvest index.

Keywords: phosphorus, cropping geometry, jatropha (*Jatropha curcus* L.) based agro-forestry and, green gram

Introduction
India posted a marginal 0.21% rise in the area under forest between 2015 and 2017, according to the biennial India State of Forest Report (SFR) 2017. The document says that India has about 7,08,273 square kilometers of forest, which is 21.53% of the geographic area of the country (32,87,569 sq.m).

When two or more plants species grow together on the same land management until, one component may influence the performance of the others components as well as the system as a whole (Nair, 1993).

The present system of intensive agriculture is nothing but a high input-output system, has hastened the peace of degeneration of soil excessive mining of the native soil fertility without replenishing nutrients trough judicious use of fertilizers or addition of crop residue. No matter how successfully the plan potential for higher productivity is expended, future gain would depend on meeting nutrient requirements of plants. This ever increasing demand for crop nutrient in a generally low fertility situation in India accompanied by a high cost of non-renewable chemical nutrient and the concern about environmental degradation and population has made it imperative to find out an eco-friendly alternative, the concept 'sustainable agriculture'. It may be described as a concept technically efficient, economically viable and environmentally sound production principle for enhanced production for the present, without affecting the quality of resource base to full fill the needs of future generation (FAO, 1989).

Jatropha is used in contour planting to prevent soil erosion or to rehabilitate eroded watersheds. Examples of such use can be found in Ethiopia, Mali and Tanzania. The situation changed in 2004-2005, when Jatropha began to be viewed globally as a possible source of biofuel. The aim of this article is to introduce *Jatropha curcas L.*and to explain what uses it has for biofuel and beyond *Jatropha curcas L.* is a monoecious shrub or small tree of on average 3-5 and up to 8 m height, with a single main straight stem and multiple secondary branches with leaves arranged alternately on the stem. The crop belongs to the genus Euphorbiaceae and can be found in many tropical and subtropical regions, roughly between 30°north and 35°south. Jatropha grows in arid and semi-arid areas, e.g. in India, and is therefore known as drought tolerant, but for seed production sufficient water is needed.

Rooting patterns are influenced by propagation methods, with direct seeding leading to one taproot, four lateral roots and many secondary roots, and propagation by cuttings generally leading to more superficial secondary roots only. The root system affects Jatropha's drought tolerance as taproots can tap into deeper soil water layers. The limitation of soil fertility hampers crop growth and production, as has been shown by fertilizer trials on waste lands in India. As a perennial crop, Jatropha stands may reach maturity and full production three to four years after planting. Over time Jatropha invests a lower proportion of it assimilates into wooden standing biomass and, if properly pruned, most assimilates become available for the seasonal growth of branches, leaves, flowers, fruits and seeds. Although singular Jatropha trees seem to be free from pests and diseases, serious problems have been reported with fungi, viruses and insect attacks in Jatropha plantations.

Jatropha yields have been estimated by many, but have only been measured by a few. Furthermore, many seed yields have been extrapolated from single trees or provenance trials to fields. A further complicating factor is that commercial varieties do not exist yet; hence when you plant seed from a single source, you may end up with a field of trees that show high variability in architecture, size and productivity.

Greengram [*Vignaradiata L.*] Originated in indo-Burma and area of South-East Asia. It is a heigh protein(23-24 %) Legume, occupies 14% of total pulses area and 7% of total pulse production in India. Pulses are an important part of profitable Agriculture because a large section of population has to rely on this as it is low priced source of protein (Usman *et al.* 2007) [6].

Green gram [*Vigna radiata* L.] (2n= 2x= 22) is third important pulse after chickpea and Pigeon pea. It is a self-pollinated crop and is an important grain legume of the tropical area. Green gram is also called mung, moong, mungo, green gram, golden gram, chick saw pea and Oregon pea. It belongs to the Family Fabaceae and sub Family Papilionaceae. The center of origin is India.

Spacing plays and an important role in contributing ti the higher yield because thick plant population will not get proper light for photosynthesis and high infestation of diseases. On the other hand very low plant poupalion will also reduce the yield. Due to this reason normal population is necessary for high yield. Advantage of optimum spacing under irrigated condition is due to reduced completion for light because when moisture is lacking, light is no longer limiting factor and the advantage of uniform spacing is lost. It is the most important non monetary input, which can be manipulated to attain the maximum production per unit area.

The phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 1986) [1]. Phosphorus shortage restricts the plant growth and remains immature. Common diagnostic properties of phosphorus deficiency are a darker green leaf colour due to higher chlorophyll contents (often with red pigments from anthocyanins), reduced leaf extension and a higher root-to-shoot ratio, since root growth is much less affected by phosphorus deficiency than shoot growth (Wild, 1988; Marschner, 1995) [7, 4].

Material and Methods

The materials, methodology and technique adopted during the course of investigation are described in this chapter under the following heads.

Experimental Site

The experiment was carried out during kharif season 2005-06 at Forest Nursery, COF, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Allahabad. U.P., which is, located at 25.57° N latitude. De 81.50° E longitude and 98 m altitude above the mean sea level. All the facilities, which are required for crop cultivation met out from the Department.

Soil of the experimental field

To ascertain physico-chemical characteristics of the soil, before sowing, soil sample were collected randomly from 0-30 cm depth from different spots of experimental field just before layout of experiment. A representative homogenous composite sample was drawn by mixing all these soil sample together. This composite soil sample was analyzed to determine the physico-chemical properties of the soil.

Design and treatment

The experiment was carried out in RBD (Randomize block design). The treatments were replicated three times and were allocated at random in each replication.

Results and Discussion

Pre-Harvest parameters

Perusal of table reveals the maximum Plant height (cm) 67.71 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 67.45 with (30x20 +40 kg P/ha$^{-1}{}_2$) treatment whereas the minimum 63.71 Plant height (cm) was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of Plant height (cm) data indicates that there was significant difference among the treatments.

Similarly, the maximum Number of trifoliate leaves 29.22 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 29.97 with (30x20 +40 kg P/ha^{-1}) treatment whereas the minimum 26.27 Number of trifoliate leaves was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of Number of trifoliate leaves data indicates that there was significant difference among the treatments.

In the case of Number of Branches per plant the maximum Number of Branches per plant 6.30 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 6.39 with (30x20 +40 kg P/ha^{-1}) treatment combination whereas the minimum 5.76. Number of Branches per plant was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of Number of Branches per plant data indicates that there was significant difference among the treatments.

Table 1: Effect of crop geometry with different levels of phosphorous on Pre-Harvest parameters of green gram (Vigna radiata L.) under Jatropha based Agroforestry

Treatments	Plant height(cm)	Number of trifoliate leaves	Number of Branches per plant
T_1-30x10+20 kg P/ha^{-1}	63.71	26.27	5.76
T_2-30x10+40 kg P/ha^{-1}	64.18	26.66	5.85
T_3-30x10+60 kg P/ha^{-1}	65.02	27.33	5.98
T_4-30x15 +20 kg P/ha^{-1}	65.25	27.77	6.18

T_5-30x15 +40 kgP/ha^{-1}	65.45	28.22	6.23
T_6-30x15 +60 kg P/ha^{-1}	67.11	28.66	6.27
T_7-30x20 +20 kg P/ha^{-1}	65.25	28.77	6.29
T_8-30x20 +40 kg P/ha^{-1}	67.45	29.22	6.30
T_9-30x20 +60 kg P/ha^{-1}	67.71	29.97	6.39
F-test	**S**	**S**	**S**
C.D.	0.774	0.054	0.061
SE(m)	0.256	0.018	0.020
SE(d)	0.362	0.025	0.028
C.V.	0.675	0.111	0.565

Post- Harvest parameters

Perusal of table reveals the maximum No. of pods per plant 38.68 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 33.13 with (30x20 +40 kg P/ha$^{-1}{}_2$) treatment whereas the minimum 16.32 No. of pods per plant was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of No. of pods per plant data indicates that there was significant difference among the treatments.

Similarly, the maximum Number of grains /pod 11.86 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 11.61 with (30x20 +40 kg P/ha^{-1}) treatment whereas the minimum 10.15 Number of grains /pod was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of Number of grains /pod data indicates that there was significant difference among the treatments.

In the case of Test weight (g) the maximum Test weight (g) 39.53 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 38.86 with (30x20 +40 kg P/ha^{-1}) treatment combination whereas the minimum 30.92 Test weight (g) was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of Number of Branches per plant data indicates that there was significant difference among the treatments. The maximum Total seed yield (q/ha) 27.40 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 25.53 with (30x20 +40 kg P/ha$^{-1}{}_2$) treatment whereas the minimum 12.44 Total seed yield (q/ha) was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of Total seed yield (q/ha) data indicates that there was significant difference among the treatments.

Similarly, the maximum Stover yield (q/ha) 32.98 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 31.11with (30x20 +40 kg P/ha^{-1}) treatment whereas the minimum 15.14 Stover yield (q/ha) was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of Stover yield (q/ha) data indicates that there was significant difference among the treatments.

In the case of Harvest index (%) the maximum Harvest index (%) 83.06 was recorded with (30x20 +60 kg P/ha^{-1}) treatment combination followed by 83.05 with (30x20 +40 kg P/ha^{-1}) treatment combination whereas the minimum 72.04. Harvest index (%) was recorded with (30x10+20 kg P/ha^{-1}) treatment. The statistical analysis of Number of Branches per plant data indicates that there was significant difference among the treatments.

Table 2: Effect of crop geometry with different levels of phosphorous on Post- Harvest parameters of green gram (*Vigna radiata L.*) under Jatropha based Agroforestry.

Treatments	No. of pods per plant	Number of grains /pod	Test weight (g)	Total seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
T_1-30x10+20 kg P/ha^{-1}	16.32	10.15	30.92	12.44	15.14	72.04
T_2-30x10+40 kg P/ha^{-1}	16.66	10.31	32.19	14.31	19.89	74.31
T_3-30x10+60 kg P/ha^{-1}	17.57	10.86	33.53	16.18	21.76	75.70
T_4-30x15 +20 kg P/ha^{-1}	20.90	11.03	34.53	18.05	23.63	76.35
T_5-30x15 +40 kgP/ha^{-1}	24.68	11.11	35.19	19.92	25.50	78.08
T_6-30x15 +60 kg P/ha^{-1}	25.57	11.18	35.53	21.79	27.16	80.20
T_7-30x20 +20 kg P/ha^{-1}	29.12	11.36	36.53	23.66	29.15	81.14
T_8-30x20 +40 kg P/ha^{-1}	33.13	11.61	38.86	25.53	31.11	83.05
T_9-30x20 +60 kg P/ha^{-1}	38.68	11.86	39.53	27.40	32.98	83.06
F-test	**S**	**S**	**S**	**S**	**S**	**S**
C.D.	0.058	0.060	0.066	0.013	1.466	7.136
SE(m)	0.019	0.020	0.022	0.004	0.485	2.360
SE(d)	0.027	0.028	0.031	0.006	0.686	3.338
C.V.	0.133	0.310	0.108	0.037	3.339	5.226

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