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Effect of shoot pruning intensity and sowing direction on growth and yield of *Green gram* (*Vigna radiata* L.) under bael (*Aegle marmelos* L.) based Agri-horti system in *Vindhyan* region

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Abstract
The present investigation entitled "Effect of shoot pruning intensity and sowing direction on growth and yield of green gram (*Vigna radiata* L.) under bael (*Aegle marmelos* L.) based Agri-horti system in *Vindhyan* region" was conducted during the *Kharif* season of 2015-2016 at Agricultural Research Farm, R.G.S.C. (BHU), Barakachha, Mirzapur (U. P.).The experiment was conducted in 9 year old bael orchard planted in 7x7 meter spacing. The experiment was laid out in randomized complete block design with agri- horti system (fruit based Agroforestry system) *i.e* bael agri-horti system. Factorial experiment was laid out in randomized complete block design having four different intensity of pruning (i.e. control, 25%, 50% and 75%) and two different level of sowing direction (North-South and East-West). Treatments were replicated thrice. Results revealed that all the growth, yield attributes, yields were increased significantly with the increasing intensity of pruning 75% pruning significantly higher growth characters like plant height (cm), dry matter accumulation (g plant^{-1}) trifoliate leaves, branches plant^{-1} and root nodules plant^{-1}as well as yield and yield attributes like pods plant^{-1}, number of grains pod^{-1}, 1000-grains weight and yield of grain kg ha^{-1}and stover with North South (NS) sowing direction. The maximum gross return, net return and benefit: cost ratio was obtained from the combined intensity of pruning 75% with NS sowing direction. Application of phosphorus at 40 kg P_2O_5 ha^{-1}, to green gram was found optimum to realize the high yield and profit under stone apple based agri-horti system. The 75% pruning intensity with North South (NS) sowing direction under agro climatic conditions of *Vindhyan* region of Mirzapur was markedly enhanced the yield and net return of green gram as compared to control under bael based agri-horti system.

Keywords: Pruning, Green gram, Bael, Agri-horti system, Agroforestry

Introduction
Agroforestry can be defined as an approach to land use that incorporates trees into farming systems, and allows for the production of trees and crops or livestock from the same piece of land in order to obtain economic, environmental, ecological, and cultural benefits (Thevathasan *et al.*, 2004) [25]. Furthermore, tree- based inter-cropping systems can result in more diversified economies for both short- and long-term products and provide a market for both agronomic and forest crops. Inter-cropping systems can also play a vital role in sequestering carbon below- and above-ground plant components, thereby addressing present and critical societal concerns about global climate change (Brandle *et al.*, 1992, Kort and Turnock, 1999) [2, 11].

Aegle marmelos L. Corr. commonly known as Bael, belonging to the family Rutaceae, is a moderate-sized, slender and aromatic and indigenous tree of India. Bael tree, fruit is reported to be a valuable Ayurvedic medicine for chronic diarrhea and dysentery, tonic for heart and brain, anti-viral activity, hypoglycemic activity and significant results against parasites and anti proliferative activity

Pulses in India are considered as the poor man's only source of protein. Pulses are grown on 29.99 million hectares of land with an annual production of 25.23 million tones in the year 2018-2019 and the productivity of pulses 841.0 kg/ ha (DES, 2019) [4]. Pulses are an important component of diet for being rich vegetarian source of protein and making diet nutritionally balanced. In spite of this, the net per capita availability of pulses has come down over the years from 61 grams per day per person in 1951 to 56 grams per day per person (DES, 2019) [4] Green gram (*Vignaradiata* L. Wilczek) is an important pulse crop having high nutritive value. Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses (Anjum *et al*. 2006) [1]. Mungbean seed contains 24.2% protein, 1.3% fat and 60.4% carbohydrate. It not only plays an important role in human diet but also in improving the soil fertility by fixing the atmospheric nitrogen (Nadeem *et al*. 2004) [14].

Pruning also reduces the competitive ability of trees, which allow the top to take advantage of the higher nutrient availability under tree cropping system. Biomass yield and productivity of crop have also been reported higher under pruned tree (Dar and Newaj, 2008) [3]. However, as the functional balance of the tree is altered through pruning, it reacts both morphologically and physiologically in response to the change consequently. The canopy tree provides shade and create conducive atmosphere for undnerneath crop to grow. Pruning of tree component is also a powerful approach to regulate this competition (Frank and Eduaro, 2003) [6]. The major management of trees in agroforestry are based on the alteration of light (solar radiation) profile and moisture distribution. The option for managing trees is many e.g. pruning, coppicing, pollarding, lopping etc. In addition, canopy management will often have direct bearing on the root characteristics as well as growth, vigor and biomass production of the tree itself (Thakur and Sehgal, 2000, 2003) [22, 23]. If sufficient recovery time is provided after pruning, such as reduction in growth gradually decreases and pruned tree resume their normal growth status. In agri-horticulture systems, presence of well-developed tree canopy and resultant shade make light an important factor in determining the potential of understory crops **(**Osman *et al*., 2011) [16]. Shoot pruning alleviates shading of crop an appeared as an effective means of increasing the light permeability and yield of intercrop (Newaj *et al.*, 2007) [15]. Sowing direction of tree planting did not influence the ground storey crops of fodder sorghum grown in association of tree (Saroj *et al.*, 1999) [20]. The effect of direction of sowing, and crop phenotype on light interception efficiency, and seed yield of Indian mustard (Jha *et al*., 2012) [9].

Material and methods

The experiment was carried out at Agricultural Research Farm, Rajiv Gandhi South Campus, Brakachha, Banaras Hindu University, Mirzapur situated at 25º 10' latitude and 82 º 37' longitudes, and at an altitude of 143 meters above mean sea level. An experiment was laid out during rainy (*Kharif*) season of 2015 in a factorial randomized complete block design. Factorial experiment was laid out in randomized complete block design having four different intensity of pruning (i.e. control, 25%, 50% and 75%) and two different level of sowing direction (North-South and East-West). Composite soil samples prior to the experiment were analyzed for different physico–chemical properties of the soil. The soil of the experimental field was sandy clay loam in texture, acidic in reaction with pH5.9, EC of 0.30 dSm^{-1}, low in organic carbon (0.33%), available nitrogen (173.71 kg ha^{-1}) and phosphorus (12.58 kg ha^{-1}) and medium in available potassium (K) (112.72 kg ha^{-1}). Field was ploughed with the help of disc plough and harrowing was done followed by planking. Recommended dose of phosphorus @ 40 kg ha^{-1} and potassium (K) @ 40 kg ha^{-1} were applied in the form of diammonium phosphate and muriate of potash respectively. Nitrogen was applied through urea as per the treatments; half as basal and remaining half was top dressed after 30 days of sowing. The rainfall received during crop season was about 513.8 mm. Recommended agronomic practices were followed to raise the crop. The Microsoft excel was used as a statistical software package for analyzing the data for the analysis of variance and other statistical parameter (Mc Cullough and Wilson 2005) [13].

Result and discussion

Effect of pruning intensity: In the present study the experiment revealed that growth parameters of green gram (Table 1) showed marked variation due to tree shoot pruning intensities. The maximum growth parameters (Table 1) viz., plant height (cm), number of branches plant^{-1} and dry matter accumulation (g plant^{-1}) at maturity, number of trifoliate leaves plant^{-1} and number of root nodules plant^{-1} at 40 DAS, yield attributes and yield (Table 2) *viz.*, pod length, no of pod plant^{-1}, no of seeds pod^{-1} Seed Yield (Kg ha^{-1}), Stover Yield (Kg ha^{-1}) and test weight and economics (Table 3) *viz.*, gross return (Rs ha^{-1}), net return (Rs ha^{-1}) and B:C ratio was recorded with 75% pruning intensity. Pruned bael trees by removing 25, 50 and 75% of the growth, and control (no pruning) and found that the numbers of new branches emerged were little affected by pruning treatment, but the average branch length and girth were greatest with the heaviest pruning Gupta and Singh (1979) [7]. Light pruned trees produced significantly higher leaf fodder and fuel wood (Kumar and Ram, 2009) [12]. Initial fruit set was higher on heavily pruned plants at 25 cm but the final retention was higher in light pruning at 75 cm with larger fruit size Awasthi and Misra (1969). This may be due to mutual competition among the plants for light, nutrients and other growth input resulting in mortality of tillers significantly probably due to increasing the production of new meristemetic tissues. Increase in number of branches due to shoot pruning intensities has also been reported by Shabir Ahmad Dar and Ram Newaj (2008) [3] and Tasso Tabin *et al.* (2015) [21]. The extent of reduction in the yield of mungbean unpruned tree may be attributed to severe competition by the tree roots which get reduced with increase in distance from tree line and shade from the bael tree also might have reduced the yield parameters near the tree. This reduction in the seed yield near the tree row may also be ascribed to lower soil moisture and low availability of light near the tree row and also harmful impact of these factors observed in the reduction of yield parameters. Similar reduction in the yield of maize, sorghum, sunflower, groundnut, mustard, wheat, urdbean, mungbean adjoining to tree line were reported by De Costa and Chandrapala, (2001), Patil and Channabasappa, (2008) [18], Patil *et al*. (2011) [17].

Effect of sowing direction: In the present study the experiment revealed that growth parameters and yield attributes and yield of green gram showed marked variation due to sowing direction. The maximum growth parameters (Table 1) viz., plant height (cm), number of branches plant^{-1} and dry matter accumulation (g plant^{-1}) at maturity, number of trifoliate leaves plant^{-1} and number of root nodules plant^{-1} at 40 DAS, yield attributes and yield (Table 2) *viz.*, pod length, no of pod plant^{-1}, no of seeds pod^{-1} Seed Yield (Kg ha^{-1}), Stover Yield (Kg ha^{-1}) and test weight and economics (Table 3) *viz.*, gross return (Rs ha^{-1}), net return (Rs ha^{-1}) and B:C ratio was recorded with NS sowing direction. This might be due to the

NS direction of sowing could also be attributed to the moisture stress created due to the competition between the tree and crop and may also be due to the reduced light intensity. The yields found in different directions of sowing are inapposite trend with the findings of (Dhingra *et al*., 1986) [5]. Since away from tree, crop had comparatively a competition free environment, it had highest number of trifoliate leaf plant^{-1}. Number of trifoliate leaf plant^{-1} at different growth stages will determine the plant architecture and contribute to the total dry matter produced plant^{-1}. The average yield of wheat crops was higher in North-South (NS) than that in East-West (EW) direction of sowing (Kler *et al*., 1989) [10]. Increased number of trifoliate leaf plant^{-1} also contributes to the total photosynthates produced vis-à-vis increase in the dry matter produced plant^{-1} (Patil *et al*. 2011) [17]. Similar result also reported by Chandrashekara (2007) and Thakur and Singh (2008) [24]. The extent of reduction in the yield of mungbean the tree row i.e. 0.5 m distance from tree base may be attributed to severe competition by the tree roots which get reduced with increase in distance from tree base and shade from the bael tree also might have reduced the yield parameters near the tree row. This reduction in the seed yield near the tree row may also be ascribed to lower soil moisture and low availability of light near the tree row and also harmful impact of these factors observed in the reduction of yield parameters. Similar result show by De Costa and Chandrapala, (2000) [8], Patil and Channabasappa, (2008) [18], Patil *et al.* (2011) [17].

Table 1: Growth parameter of mungbean as influenced by sowing direction and shoot pruning intensity under bael based agri-horti system.

Treatment	Growth parameter				
	Plant Height (cm)	Number of Branches plant^{-1}	Number of Trifoliate Leaves plant^{-1}	Number of Root Nodules at 40 DAS plant^{-1} (g)	Dry Matter Accumulation plant^{-1} (g)
Pruning intensity					
0% control	45.00	4.99	4.09	10.02	9.42
25% pruning	46.50	5.66	4.12	11.17	9.65
50% pruning	46.83	6.20	4.24	11.92	9.72
75% pruning	51.50	6.42	4.63	12.08	10.90
S.Em. ±	2.11	0.21	0.19	0.51	0.44
CD at 5%	4.52	0.45	0.41	1.10	0.95
Sowing Direction					
EW Direction	45.33	5.51	4.10	10.65	9.56
NS Direction	49.58	6.12	4.45	11.94	10.28
S.Em. ±	1.49	0.14	0.14	0.36	0.31
CD at 5%	3.20	0.32	0.29	0.78	0.67

Table 2: Yield attributes of mungbean as influenced by sowing direction andshoot pruning intensity under bael based agri-horti system.

Treatment	Yield Attributes					
	Pod length (cm)	No of pod plant-^{1}	No of seed pod-^{1}	Seed Yield (Kg ha^{-1})	Stover Yield (Kg ha^{-1})	Test weight (g)
Pruning intensity						
0% control	6.05	9.53	9.05	810	2552	26.07
25% pruning	6.19	9.85	9.20	879	2677	28.57
50% pruning	6.36	9.92	9.36	912	2895	28.87
75% pruning	6.80	10.95	10.29	987	2907	29.67
S.Em. ±	0.25	0.40	0.42	52	133	1.13
CD at 5%	0.54	0.86	0.89	112	286	2.43
Sowing Direction						
EW Direction	6.15	9.69	9.04	856	2639	27.22
NS Direction	6.55	10.43	9.91	938	2876	29.32
S.Em. ±	0.18	0.28	0.29	37	94	0.80
CD at 5%	0.38	0.61	0.63	79	202	1.72

Table 3: Yield attributes of mungbean as influenced by sowing direction and shoot pruning intensity under bael based agri-horti system.

Treatment	Economics		
	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C Ratio
Pruning intensity			
0% control	79264	52710	1.99
25% pruning	85816	58482	2.14
50% pruning	89288	61173	2.18
75% pruning	96127	67233	2.33
S.Em. ±	4723	4723	0.17
CD at 5%	10129	10129	0.36
Sowing Direction			
EW Direction	83653	55929	2.02
NS Direction	91595	63870	2.30
S.Em. ±	3339	3339	0.12
CD at 5%	7162	7162	0.26

Relative economics

The data indicated that the variety Samarat recorded through 75% shoot pruning intensity at NS direction of sowing, the maximum gross return (96127 Rs ha^{-1}), net return (67233 Rs ha^{-1}), and B.C. ratio (2.33%) which was higher than other treatment. Similar B.C. ratio was found in Aonla based agroforestry system Ram Newaj and Rai, 2005 [19] and Thakur and Singh, 2008 [24].

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