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RESEARCH ARTICLE

Effect of organic manures and land configuration on growth and yield of rice bean [*Vigna umbelletta* (Thunb.) Ohwi and H. Ohashi] in Sikkim Himalayan Region

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SUMMARY

Rice bean is an important underutilised pulse crop of Sikkim and Himalayan region and mostly it is grown organically on the terraces with locally available organic nutrient sources. The aim of the study was to understand the effect of locally available organic manuresand land configuration on growth and yield of the rice bean crop. Among the organic manure treatments, OM_4 (FYM + mixed compost + vermicompost + poultry manure) has resulted into higher growth and yield followed by OM_3 (FYM + mixed compost + vermicompost) and OM_2 (FYM + mixed compost). The higher growth and yield in OM_4 might be due to continuous supply of desirable nutrients to the crop throughout the seasons. Whereas, rice bean had comparatively lower growth and yield in OM_1 and OM_2 treated plants which might be due to less available nutrient content in FYM and mixture of FYM and mixed compost for desirable growth and yield. So, integrated application of FYM ($^1/_4$ RDN), mixed compost ($^1/_4$ RDN), + vermicompost ($^1/_4$ RDN), + poultry manure ($^1/_4$ RDN) would be helpful for farmers for achieving higher yield of rice bean. Among the land configuration techniques studied, ridge and furrow followed by broad bed and furrow techniques had resulted into higher growth and yield of the crop, which might be due to higher nutrient and moisture availability to the rice bean crop under ridge and furrow as well as broad bed furrow beds through positive impact of effective drainage of excessive rain water onhigher activities of soil microbes and enzymesin rhizospheric soil.

Key Words : Rice bean, Land configuration, Organic manures, Vigna, Mixed compost

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As we all know legume crop is very important for our regular diet and it is a very important source of dietary vegetarian protein. There are varieties of underutilized legumes available in the state of Sikkim among which rice bean is one of the most potential crops

with high nutritional value. Rice bean is mainly cultivated as fodder crop to feed the cattle, but it is also cultivated as legume crop in Sikkim hilly regions. The nutritional quality of rice bean is higher as compare to many other legumes of Vigna group since it has high protein content and rich in amino acids like methionine and tryptophan (Chandel *et al.,* 1978) as well as mineral content and vitamins including thiamine, riboflavin, niacin and ascorbic acid. Rice bean (*Vigna umbelletta*) is a crop which helps to improve soil health by adding nitrogen to the soil and also improves human health by adding protein content to the regular diet of the marginal people of the hilly region in a very economical way. Though it is a nutrient rich crop, but this crop is cultivated only in small areas by subsistence farmers in hills of north east, western and north India. Proper cultivation practices need to be popularized for up scaling rice bean cultivation to make the crop popular among farmers. In North Eastern Hill Region, rice bean is traditionally cultivated mostly with organic inputs as a source of nutrients, but there is no adoption of scientific package of practices for rice bean. Use of sufficient quantity of organic based nutrient also has many beneficial impacts as it improves soil tilth, infiltration rate and soil water holding capacity, soil microbial properties (Belay*et al.* 2001)and contributes nutrient to the crop. Nutrients contained in organic manure are released slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Sharma and Mitra, 1991).Soil loss can also be controlled by application of organic manure in different form (FYM, poultry manure, vermicompost, mixed compost etc.) which will increase the binding capacity of the soil and also helps to improve soil water holding capacity and maintain proper porosity. Application of organic manure as soil amendment is to immobilize Fe and Al through solubilization and thereby improving nutrient supplying capacity of soil (Venkatesh *et al.* 2002). Soil application of organic manure produced from diverse sources, like cattle manure, pig manure, food and agricultural waste, forest litter, weed biomass etc., is helpful to improve soil structure, growth and yield of crops (Atiyeh *et al.* 2000), restore the soil organic matter (SOM) and off-set disruption of nutrient cycling caused by intensive agricultural practices (Lai 2004, Miguel *et al.* 2019). Organic manure influences soil productivity through the effect on soil physico- chemical and biological properties (Das *et al.* 2004, 2017). So, proper and timely use of organic sources of nutrient results in higher yield and quality of rice bean. In this regard, detail study need to conduct to standardize the application of different organic manures for fulfillment of nutrient requirement in achieving the higher yield and quality of rice bean.

In Sikkim and Himalaya region, rice bean is normally cultivated on terraces during post Kharif and pre Rabi season. So, it receives very high rainfall mostly in early growth period. Due to heavy rainfall, fertile top soil used to get eroded and this is the major problem in hilly track for sustainable production of any crop and many a time cultivable lands generally became very less fertile. Techniques of land configuration arefound effective to restrict the soil erosion and maintain soil health for crop growth.Land configuration techniques (broad bed and furrow, ridge and furrow, raised bed) are mostly used for different types of crop production. Other than that land configuration techniques are also helpful for effective drainage in the field for removal of excess water and it has positive impact on overall crop growth and higher activity of soil microbial population. The raised bed/bun cultivation practiced at higher elevation is a modified form of shifting cultivation adopted for better utilization of limited land and biomass (Poreba and Prokop 2011). These methods of cultivation are not sustainable and make land unfit for cultivation in long run. So, there is need of application of organic manures and land configuration of cultivated lands for achieving higher yield of the rice bean crop.

MATERIAL AND METHODS

The field experiment was conducted under rainfed terrace condition at experimental farm of National Organic Farming Research Institute, Tadong, Gangtok, Sikkim for two consecutive years during 2014 and 2015. The experimental site is located at 27°20'N latitude, 88°37'E longitude and altitude of 1350 m above mean sea level. The soil of the experimental was clayey loam in nature. The annual average rainfall of the experimental site is 3250 mm and monsoon prevailed normally during June to early October, whereas dry period prevails during November to March-April.The maximum temperature ranges from 10.8°C to 31.7°C and the minimum temperature ranges from 4.2°C to 22.6°C.Maximum relative humidity ranges from 75 to 99 % in the year 2014 and 25 to 96 % in the year 2015. Bright sun shine hour varies from a minimum (0 hour) in the month of June to a maximum (8.8 hours) in the month of November.

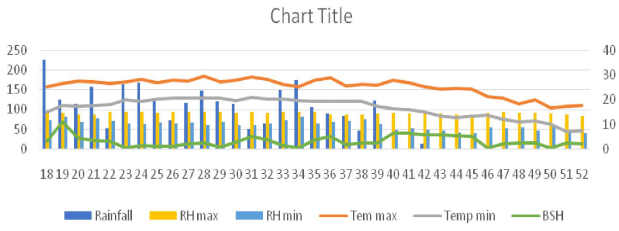

Fig. 1: Graphical representation of weather data during the crop season in 2014

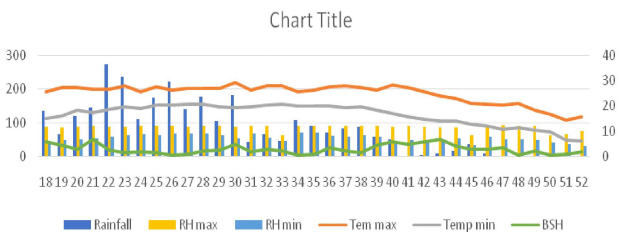

Fig. 2: Graphical representation of weather data recorded during crop season in 2015

Treatment details:

The experiment was laid out in Split plot design with three replications. There were three main plot treatments (L_1: Flat bed, L_2: Broad bed and furrow and L_3: Ridge and furrow) and five sub plot treatments (OM_0: Control, OM_1: RDN through FYM, OM_2: ½ RDN through FYM + ½ RDN through mixed compost, OM_3: $^1/_3$ RDN through FYM + $^1/_3$ RDN through mixed compost + $^1/_3$ RDN through vermicompost, OM_4: ¼ RDN through FYM + ¼ RDN through mixed compost + ¼ RDN through vermicompost + ¼ RDN through poultry manure).

Organic manures were applied 20 days prior to sowing on nitrogen equivalent basis to supply recommended dose of nitrogen.The well decomposed FYM, mixed compost, vermicompost and poultry manure were procured from the farm. N, P_2O_5 and K_2O contents in FYM are 0.5%, 0.3% and 0.5%, in mixed compost are 0.5%, 0.25% and 0.5%, in vermicompost are 3%, 1% and 1.5%, in poultry manure are 3.03%, 2.6% and 1.4%.

Cultivation method:

Application of FYM, mixed compost, vermicompost and poultry manure had been done as per the treatments of the study and then mixed properly with soil of each bed before sowing. The famous variety of rice bean Mauyang Light Brown was taken for this study. A seed rate of 20 kg ha^{-1} was taken for this experiment and two or three seeds were placed at depth of 3-5 cm at a spacing of 60 cm from row to row and 30 cm from plant to plant.Two ploughing was done by power tiller operator and then leveling by wooden plank at the time of land preparation.

Manual weeding was done for four times to remove the weeds upto critical period of crop weed competition at 15, 30, 45 and finally 60 days after sowing. No irrigation was provided to the crop as experiment was carried out during *Kharif* to *Pre-Rabi* season. Disease and pest problems were very less in this crop, so no measure was taken for plant protection.

Plant and soil sampling and analysis :

Periodical crop samples were taken from two random areas in every plot. Sampling techniques were strictly followed for all the growth and yield characters including estimation of yield as per standard procedures (Gomez, 1972). Plant height, number of branches and number of leaves were measured on 10 randomly selected plants from each plot of every treatment combination and the average was presented. Leaf area index was worked out following the formula suggested by Palaniswami and Gomez (1972). Dry matter production and crop growth rate were calculated at 30 days interval using the standard method and formula of Watson (1958), respectively.

Standard method was followed for estimation of root volume and root dry weight.Number of pods per plant, number of seeds per pod, 100 seed weight was calculated following standard methods. Seed and stover yield were calculated at 9% moisture basis as suggested by Yashida *et al.* (1976). Harvest index (HI) was calculated by using the formula suggested by Donald and Humblin (1976).

Soil fertility and residual nutrient content of the experimental plot was analysed by taking pre experimental composite sample from 0-30 cm depth. Available N, P, K, Zn, Cu, B and Mn of all the sample taken were estimated following standard methods.

The data on various studies recorded during the investigation were subjected to statistical analysis as suggested by Gomez and Gomez (1984) to find out the best treatment and significant difference between treatment based on critical difference (CD) worked out a 5% probability level and values were furnished accordingly and denoted as 'S'. The non-significant differences were denoted as 'NS'.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth of rice bean:

The considerable differences in the result of growth parameters was observed in all the methods of land configurations. In case of plant height, broad bed and furrow method showed better result as compare to ridge and furrow method in all the observations. The growth parameters like number of leaves, number of branches, leaf area index, root volume, root length, number of nodules, dry weight etc. gave better result in ridge and furrow method and broad bed and furrow method as compare to flat bed method.

The sufficient variation was observed among the different growth parameters of rice bean after organic manuring through sole and conjunctive application. Within the growth parameters the maximum plant height, number of branches, number of leaves was observed in OM_4 (¼ RDN through FYM + ¼ RDN through mixed compost + ¼ RDN through vermicompost + ¼ RDN through poultry manure) followed by OM_3 ($^1/_3$ RDN through FYM + $^1/_3$ RDN through mixed compost + $^1/_3$ RDN through vermicompost). Leaf area index was found maximum in OM_4 followed by OM_3. Root length, root volume was also recorded highest in OM_4, but the result of root volume was statistically at par with OM_3 in pooled analysis. Number of nodules was counted maximum in OM_4 followed by OM_3whereas very less number of nodules were observed in OM_0 (Control).

Yield parameters:

In the analysis of land configuration, ridge and furrow method showed better result in number of pods per plant and number of seeds per pod which was followed by broad bed and furrow method. In all the yield parameters, pod yield, seed yield and biological yield the trend was same. 26.9 q/ha of pod yield, 19.5 q/ha of seed yield and 142.1 q/ha of biological yield were recorded as highest. Maximum 100-seed wight of 22.8 g was recorded in ridge and furrow method. Shelling percentage of 73.8 and 73.2 were recorded in ridge and furrow method and broad bed and furrow method. Highest harvest index was recorded in broad bed and furrow method.

Under the experiment, observation had been taken to understand the differences in the effect of different organic manures applied as a sole treatment in combination. Among the yield parameters the maximum number of pods were observed in OM_4 (¼ RDN through FYM + ¼ RDN through mixed compost + ¼ RDN through vermicompost + ¼ RDN through poultry manure) (108 in number) followed by OM-$_1$ (RDN

Table 1: Influence of land configuration and organic manuring on number of pods /plant, number of seeds/ pod, pod yield, seed yield and biological yield

	Number of pods /plant	Number of seeds/pod	Pod yield (q/ha)	Seed yield (q/ha)	Bioogical yield (q/ha)
Land configuration					
L_1	83	9	23.6	16.6	126.2
L_2	83	8	25.5	18.2	133.9
L_3	112	9	26.9	19.5	142.1
S.E.±	2.5	0.2	0.3	0.2	1.6
C.D. (P=0.05)	9.5	0.7	1.2	0.9	6.2
Organic manuring					
OM_0	79	8	21.2	14.8	105.9
OM_1	94	9	23.5	16.7	119.5
OM_2	91	9	24.7	17.7	132.0
OM_3	90	9	27.5	19.9	148.9
OM_4	108	9	29.7	21.4	163.9
S.E.±	3.9	0.3	0.2	0.2	1.6
C.D. (P=0.05)	11.5	0.8	0.6	0.5	4.6

L_1: Flat bed, L_2: Broad bed and furrow, L_3: Ridge and furrow.OM_0: Control, OM_1: RDN through FYM, OM_2: ½ RDN through FYM+ ½ RDN through mixed compost, OM_3: $^1/_3$RDN through FYM + $^1/_3$RDN through mixed compost+ $^1/_3$RDN through vermicompost, OM_4: ¼RDN through FYM + ¼RDN through mixed compost+ ¼RDN through vermicompost+ ¼ RDN through poultry manure

through FYM) (94). Whereas, the effect of OM_3 ($^1/_3$ RDN through FYM + $^1/_3$ RDN through mixed compost + $^1/_3$ RDN through vermicompost) and OM_2 (½ RDN through FYM + ½ RDN through mixed compost) on number of pods of rice bean was statistically non-significant. The maximum number of seeds per pod was counted in OM_4 in both the years. In pooled analysis, the maximum pod yield of 29.7 q/ha was recorded in OM_4 treated plot and followed by pod yield of 27.5 q/ha in OM_3. The similar trend of effect through conjunctive application of organic manure in treatmentOM_4 was observed as maximum seed yield and which followed by OM_3. 44.6 % and 34.5% more seed yield was observed in $OM_4$and OM_3 as compared to OM_0 (Control). Pooled analysis on biological yield exhibited that the highest yield of 163.9 q ha^{-1} was recorded in OM_4 followed by OM_3 (148.9 q ha^{-1}) and OM_2 (132.0 q ha^{-1}). The maximum weight of 100 seed was recorded in OM_4 (22.7 g) followed by OM-$_1$ (21.5 g). In pooled analysis the highest shelling percentage was recorded in OM_4i.e. 74.3. The shelling percentage in OM_3 was at par with OM_2. Maximum harvest index of 21.3 was observed in OM_4which was at par with OM_3.

In the present study, sole and conjunctive application of FYM, mixed compost, vermicompost and poultry manure had resulted into higher growth of rice bean as compare to control. Data revealed that the conjunctive application FYM, mixed compost, vermicompost and poultry manure significantly influenced the growth of rice bean crop as compared to sole application of FYM. Integrated application of different compost was applied by the combinations of different organic manures viz. (OM_0: Control, OM_1: RDN through FYM, OM_2: ½ RDN through FYM + ½ RDN through mixed compost, OM_3: $^1/_3$ RDN through FYM + $^1/_3$ RDN through mixed compost + $^1/_3$ RDN through vermicompost, OM_4: ¼ RDN through FYM + ¼ RDN through mixed compost + ¼ RDN through vermicompost + ¼ RDN through poultry manure)in rainfed condition of Sikkim Himalayan region. The effectiveness of integrated application of four organic manures (when provided on nitrogen equivalent basis) might be due to larger volume of organic matter applied through FYM, mixed compost, vermicompost and poultry manure. The integrated application of FYM (a wider C:N:P ratio manure) and vermicompost (a narrow C:N:P ratio manure) might have increased the mineralization of native nitrogen and also release of plant growth substances from vermicompost (Hazarika et al. 2006) in a persistent manner during the entire growth period (Patel et al. 2015; Parmar et al. 2018). Soil physical properties such as bulk density, water holding capacity and percent of water soluble aggregation were noted to favorably influence by application of different organic manure (Vengadaramana and Jashothan, 2012).

The higher yield with integrated application of different organic manures could be due to the fact that FYM contain more organic matter and VC is rich in plant growth substances like hormones, auxins, vitamins,

Table 2: Influence of land configuration and organic manuring on 100 seed weight, shelling percentage and harvest index

	100 seed weight (g)	Shelling percentage	Harvest index
Land configuration			
L_1	19.6	72.5	19.2
L_2	21.7	73.2	21.1
L_3	22.8	73.8	20.3
S.E.±	0.4	0.9	3.9
C.D. (P=0.05)	1.7	3.6	11.6
Organic manuring			
OM_0	20.1	72.1	20.2
OM_1	21.5	72.6	20.2
OM_2	21.4	73.3	20.4
OM_3	21.4	73.7	21.0
OM_4	22.7	74.2	21.3
S.E.±	0.4	1.2	7.2
C.D. (P=0.05)	1.2	3.6	18.6

L_1: Flat bed,L_2: Broad bed and furrow, L_3: Ridge and furrow.OM_0: Control, OM_1: RDN through FYM, OM_2: ½ RDN through FYM+ ½ RDN through mixed compost, OM_3: $^1/_3$RDN through FYM + $^1/_3$RDN through mixed compost+ $^1/_3$RDN through vermicompost, OM_4: ¼RDN through FYM + ¼RDN through mixed compost+ ¼RDN through vermicompost+ ¼ RDN through poultry manure

antibiotics and beneficial microorganisms (Hazarika *et al.,* 2006), An improvement of soil structure due to effective aggregation might have increased the water holding capacity and air permeability in the soil (Vengadaramana *et al.,* 2012). The decomposition of organic matter releases organic acids during microbial decomposition of organic matter which might have helped in solubilization of native phosphorus resulted in formation of phospho-humic complex. Such phospho complex may easily be assimilated by plants (Das *et al.,* 2014a). Integrated use of different type of organic manures might have increased the level of soil organic carbon and it has positive impact on soil nutrient availability to the plant and overall improvement of soil health (Kundu *et al.,* 2007 and Ozlu *et al.,* 2019). The increase in available P might be due to release of organic acids during microbial decomposition of OM, which helped in solubility of native phosphates (Bhardwaj and Omanwar, 1994). Poultry manure was added as component of integrated manuring which showed positive effect for better growth during early stage leading to desirable growth and yield as poultry manure significantly produced the highest soil chemical properties, this could be related to its lowest C: N ratio, lignin and lignin: N ratio, which favours quick mineralization and release of nutrients to the soil compared with other soil amendments (Aruna *et al.*, 2020). Higher potassium level might be due to positive effect of organic matter to release K from non exchange fraction to the available pool.

The differences in soil organic carbon and available nutrients in soil with application of different organic manures amendments are mostly due to differential rate and time of oxidation, mineralization by microbes and their diverse residence periods. So, the maximum growth and yield observed under conjunctive application of four different organic manures might be due to overall improvement of soil physico-chemical and biological properties leading to higher soil moisture, air permeability and level of available nutrients at different stages of growth of rice bean plant. Therefore, it can be highlighted to apply diverse locally available organic manure in combination for achieving better yield and quality of rice bean under rainfed and terrace condition of Sikkim Himalayan region with minimum input cost and good soil health.

In this study, the poor performance of rice bean under the flat bed was observed, which might be due to water stagnation during the period of active crop growth and development stages resulting into poor root growth, leaf expansion; dry matter accumulation and photosynthesis rate (Ren *et al.* 2016 and Masunaga *et al.* 2018). Contrary to flat bed, ridge and furrow and broad bed and furrow systems facilitated for effective drainage of excessive rainwater from experimental plots and which was helpful towards good soil aeration, better nutrient availability to rice bean plants leading to the higher LAI, yield parameters and yield of the crop (Fahong *et al.* (2014); Schmidt and Zemadim, 2015). Better drainage

Table 2: Influence of land configuration and organic manuring on 100 seed weight, shelling percentage and harvest index

	100 seed weight (g)	Shelling percentage	Harvest index
Land configuration			
L_1	19.6	72.5	19.2
L_2	21.7	73.2	21.1
L_3	22.8	73.8	20.3
S.E.±	0.4	0.9	3.9
C.D. (P=0.05)	1.7	3.6	11.6
Organic manuring			
OM_0	20.1	72.1	20.2
OM_1	21.5	72.6	20.2
OM_2	21.4	73.3	20.4
OM_3	21.4	73.7	21.0
OM_4	22.7	74.2	21.3
S.E.±	0.4	1.2	7.2
C.D. (P=0.05)	1.2	3.6	18.6

L_1: Flat bed,L_2: Broad bed and furrow, L_3: Ridge and furrow.OM_0: Control, OM_1: RDN through FYM, OM_2: ½ RDN through FYM+ ½ RDN through mixed compost, OM_3: $^1/_3$RDN through FYM + $^1/_3$RDN through mixed compost+ $^1/_3$RDN through vermicompost, OM_4: ¼RDN through FYM + ¼RDN through mixed compost+ ¼RDN through vermicompost+ ¼ RDN through poultry manure

during early growth stages of crops under raised bed might have provided favourable soil conditions to the plants leading to improvement in growth and yield (Das *et al.,* 2012). Higher yield in ridge and furrow beds followed by broad bed and furrow beds might be due to improvement in overall soil health favourable to root development, which helped in acquiring sufficient soil water and nutrients for better growth and development of the crop (Bakht *et al*., 2006).

Summary and conclusion:

The present study highlighted that effective use of organic nutrient sources through integrated organic manuring would be helpful for achieving higher yield and maintain soil health through environmentally safe approach. Organic manuring along with application of suitable land configuration techniques like ridge and furrow system and broad bed furrows system would have complementary impact on sustainable soil health and achieve higher yield of rice bean crop.

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