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Effect of tillage practices and fertility levels on growth analysis, yield of clusterbean and residual soil nutrients

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Abstract
A field experiment was conducted during *kharif* seasons of 2016 and 2017 at the Research Farm, College of Agriculture, Gwalior (M.P.) to study the effect of tillage practices and fertility levels on growth analysis parameters, yield of clusterbean and residual soil nutrients. The treatments comprised of four levels each of tillage system and fertility levels were evaluated in split plot design with three replications. The AGR, CGR, RGR and NAR increased upto maximum extent when minimum tillage (MT) having one cultivation plus 3 t/ha wheat residue (WR). The conventional tillage with three cultivations record the lowest growth analysis parameters. The total biomass production under MT + WR was upto 59.08 q/ha over the conventional tillage (51.29 q/ha). The application of 100% RDF ($N_{20}P_{40}K_{20}$) augmented all these growth analysis parameters significantly over the lower NPK levels. The total biomass produced was upto 59.0 q/ha over zero NPK (50.8 q/ha). The residual available N, P and K after harvest of clusterbean was found highest under 100% RDF (recommended dose of fertilizers).

Keywords: Fertility levels, tillage practices, growth analysis, clusterbean

Introduction
The crop production is the practical means of tapping solar energy and converting it into food and other usable materials through the production of leaves. The surface area of leaves per plant is the important determinant in the production of photosynthates. The leaf area index describes the functional size of assimilatory apparatus of plant stand and serves as a primary values for the calculation of other growth analysis parameters. Looking to the fact that production of leaves (photosynthetic surface area) depends on the supply of nutrients from the well-prepared soil conditions. The proper tillage system can impact soil moisture status because tillage influences the infiltration, run-off, evaporation and soil moisture storage. Due to several reasons no till or reduced tillage has been found more beneficial than the conventional tillage (Cara *et al.*, 2010 and Javeed *et al.*, 2013) [2, 4]. The organic manures and crop residues are important constituents of integrated nutrient management which improves physico-chemical and biological properties of the soil and consequently crop yield on sustainable basis (Sunil Kumar *et al.*, 2018) [12]. The clusterbean is a *kharif* legume, being drought tolerant and hardy, the crop is cultivated under rainfed conditions. Its deep penetrating root system enables the plant to utilize soil moisture more efficiently and offers better scope for rainfed cropping. Looking to all these facts, it was essential to find out the suitable tillage practice under integrated nutrient management for clusterbean cropping under the existing agro-climatic conditions of Gwalior region.

Material and methods
The field experiment was conducted was carried out at the Research farm, College of Agriculture, Gwalior (M.P.) during *kharif* seasons of 2016 and 2017. The soil of the experimental field was silty clay-loam having pH 8.0, electrical conductivity 0.12 dS/m, organic carbon 4.61 g/kg, available nitrogen, phosphorus and potassium 216.0, 16.52 and 284 kg/ha, respectively. The total rainfall received during the crop season was 461.6 and 458.7 mm in 2016 and 2017, respectively. The treatments comprised of four tillage systems (conventional tillage with 3 cultivations, minimum tillage with 1 cultivation, conventional tillage + 3 t/ha wheat residue, minimum tillage + 3 t/ha wheat residue as the main-plot treatments and four fertility levels (control, 50, 75 and 100% RDF i.e. $N_{20}P_{40}K_{20}$) as the sub-

plot treatments. The experiment was laid out in split-plot design with three replications. Clusterbean var. HG-563 was sown on 18 and 10 July 2016 and 2017, respectively @ 20 kg seed/ha in rows 45 cm apart. The crop was grown as per recommended package of practices under rainfed conditions. The growth analysis parameters were calculated as per recommended formula. The crop was harvested on 2 and 5 November 2016 and 2017 respectively.

Results and discussion

Growth analysis parameters

The scrutiny of data in Table 1 reveal that the effect of tillage practices upon AGR was observed upto significant extent only beyond 60 DAS of plant growth. The minimum tillage (MT) + wheat residue (WR) proved most favourable to enhance plant growth upto maximum extent, being significant over to conventional tillage (CT) only. That means MT as well as MT or CT alongwith WR performed equally better to enhance this parameter (0.637-0.655 g/day at 60-90 DAS and then 0.477-0.496 g/day at 90 DAS to harvest). The lowest AGR values were 0.608 and 0.446 g/day in case of CT during the respective stages.

The applied tillage practices exerted significant deviation on CGR almost at every growth stage except during 60-90 DAS stage. MT + WR performed the best favourable soil conditions to create maximum increase in CGR. Consequently, the CGR starting from 0.134 g/dm^2/day during 0-30 DAS reached upto 0.426 g/dm^2/day during 90 DAS to maturity stage. Whereas under conventional tillage, the CGR starting from 0.120 g/dm^2/day at 0-30 DAS reached 0.334 g/dm^2/day during maturity stage.

Table 1: Absolute growth rate (g/day) and crop growth rate (g/dm^2/day) of clusterbean as influenced by tillage practices and fertility levels (Mean of two years)

Treatments	Absolute growth rate (g/day)				Crop growth rate (g/dm^2/day)			
	(0 - 30 DAS)	(30 - 60 DAS)	(60 - 90 DAS)	(90 DAS to harvest)	(0 - 30 DAS)	(30 - 60 DAS)	(60 - 90 DAS)	(90 DAS to harvest)
Tillage practices								
Conventional	0.055	0.153	0.608	0.446	0.120	0.331	0.338	0.334
Minimum	0.056	0.162	0.637	0.477	0.128	0.340	0.343	0.430
Con.+ wheat residue	0.057	0.161	0.638	0.465	0.129	0.338	0.337	0.414
Mini.+ wheat residue	0.060	0.163	0.655	0.496	0.134	0.343	0.344	0.426
C.D. (P=0.05)	NS	NS	0.039	0.034	0.005	0.006	NS	0.033
Fertility levels(kg/ha								
Control	0.052	0.150	0.609	0.451	0.123	0.332	0.336	0.384
50% RDF	0.057	0.155	0.645	0.468	0.126	0.337	0.338	0.387
75% RDF	0.062	0.170	0.646	0.499	0.128	0.340	0.344	0.406
100% RDF	0.059	0.163	0.640	0.472	0.135	0.343	0.344	0.427
($N_{20}P_{40}K_{20}$)								
CD (P=0.05)	NS	NS	0.031	0.041	0.006	0.007	NS	0.043
Interaction	NS	NS	Sig.	Sig.	Sig.	Sig.	NS	Sig.

Con. = Conventional; Mini. = Minimum; NS = Non significant; Sig. = Significant

The data in Table 2 revealed that the same tillage treatment MT + WR resulted in maximum RGR at every stage. The maximum values were 0.180, 0.351, 0.291 and 0.234 g/g/day at the respective stages. This was closely followed by CT + WR and then MT. Similarly, MT + WR resulted in significantly higher NAR over the remaining tillage practices at every stage of plant growth (0.234 to 0.240 g/dm^2/day at different stages). On the other hand, conventional tillage (CT) recorded significantly lowest NAR (0.162 to 0.219 g/dm^2/day).

Table 2: Relative growth rate (g/g/day) and net assimilation rate (g/dm^2/day) of clusterbean as influenced by tillage practices and fertility levels (Mean of two years)

Treatments	Relative growth rate (g/g/day)				Net assimilation rate (g/dm^2/day)			
	(0 - 30 DAS)	(30 - 60 DAS)	(60 - 90 DAS)	(90 DAS to harvest)	(0 - 30 DAS)	(30 - 60 DAS)	(60 - 90 DAS)	(90 DAS to harvest)
Tillage practices								
Conventional	0.0160	0.0334	0.280	0.222	0.322	0.214	0.212	0.162
Minimum	0.0160	0.0342	0.283	0.232	0.227	0.228	0.229	0.229
Con.+ wheat residue	0.0170	0.0337	0.284	0.231	0.231	0.233	0.231	0.231
Mini.+ wheat residue	0.0180	0.0351	0.291	0.234	0.238	0.234	0.240	0.237
C.D. (P=0.05)	0.0013	0.0013	0.0076	0.003	0.0049	0.0041	0.003	0.042
Fertility levels(kg/ha								
Control	0.0160	0.0327	0.276	0.223	0.223	0.216	0.222	0.197
50% RDF	0.0170	0.0346	0.288	0.227	0.226	0.225	0.226	0.205
75% RDF	0.0170	0.0341	0.286	0.234	0.231	0.230	0.231	0.227
100% RDF	0.0170	0.0351	0.289	0.237	0.234	0.237	0.235	0.236
($N_{20}P_{40}K_{20}$)								
CD (P=0.05)	0.0014	0.0014	0.0016	0.003	0.0047	0.0033	0.002	0.029
Interaction	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

Con. = Conventional; Mini. = Minimum; NS = Non significant; Sig. = Significant

The significant increase in all these physiological attributes of clusterbean due to minimum tillage + 3 t/ha wheat residue might be owing to the better physico-chemical properties of the soil and enhanced availability of nutrients and soil

moisture and thereby effective conversion of multinutrients at the site of photosynthesis into pigments (Sharma *et al.*, 2011; Ayub *et al.*, 2012; Sharma and Jain, 2012; Javeed *et al.*, 2013 and Sunil Kumar *et al.*, 2018) [8, 1, 9, 4, 12].

Amongst the applied NPK fertility levels (Table 1), 50, 75 and 100% RDF augmented AGR upto same extent i.e. without any significant differences (0.640-0.646 g/day) during 60-90 DAS stage and 0.468-0.499 g/day during 90 DAS to harvest stage). Consequently, the lowest AGR values (0.609 and 0.451 g/day) under respective stages were obtained from the control treatment. Similarly, the maximum CGR under 100% RDF at 0-30 DAS was 0.135 g/dm^2/day which reached upto 0.427 g/dm^2/day at 90 DAS to harvest stage. Whereas in control treatment the CGR starting from 0.123 g at 0-30 DAS went only 0.384 g/dm^2/day upto maturity stage.

The RGR values under 100% NPK were also maximum at different stages of plant growth (Table 2). The RGR declined with the decrease in the fertility levels. Therefore, the RGR values were found lowest under the control treatment. The 100% RDF resulted in significantly higher NAR over the preceding fertility levels almost at every stage of plant growth. Accordingly, NAR at different stages ranged from 0.234 to 0.237 g/dm^2/day. In contrast the NAR in control was found significantly lowest range (0.197 to 0.222 g/dm^2/day) from beginning to harvest stage.

The significant increase in AGR, CGR, RGR and NAR due to combined NPK fertilizer nutrition might be owing to better availability of nutrients and effective conversion of multi-nutrients at the site of photosynthesis into pigments. In fact, the combined function of NPK nutrients might have maximum photosynthate accumulation towards the leaf biomass, because in the initial stage, leaf is the more powerful sink than any other plant parts in most of the crops (Singh *et al.*, 2014) [11]. Thus, the number of leaves/plant justified the ultimate final expression of AGR, RGR, CGR and NAR of the growing plants.

Total biomass production

Adoption of minimum tillage + 3 t/ha wheat residue resulted in total biomass upto 59.08 q/ha, whereas the lowest value (51.29 q/ha) was obtained from CT. The difference was upto 7.80 q/ha. Similarly, 100% RDF recorded maximum total biomass upto 59.00 q/ha as against 50.86 q/ha in case of control, difference being 8.13 q/ha. The higher biomass production was due to efficient and greater partitioning of metabolites towards reproductive structures. These results agree with those of Singh (2018) [10], Pandey *et al.* (2018) [6] and Gadi *et al.* (2018) [3].

Residual soil nutrients

The available –N in soil was found identical (225.0 to 227.2 kg/ha) under MT, CT + WR and MT + WR tillage practices but these practices exerted significantly impact over CT (221.0 kg/ha) as revealed from Table 3. The available-P in post-harvest soil was found statistically at par under each of the tillage practices (17.95 to 20.06 kg/ha). However, available-K was found significantly higher (309.7 kg/ha) as compared to all the remaining tillage practices. The second best treatment was CT + WR (301.8 kg K/ha) which proved significantly superior to MT (296.3 kg K/ha). The CT resulted in significantly lowest available-K (282.5 kg/ha) in the post-harvest soil. These results agree with those of Sharma and Jain (2012) [9], Khumhar *et al.* (2013) [5] and Sunil Kumar *et al.* (2018) [12].

Table 3: Total biomass (q/ha) and soil fertility in post-harvest soil of clusterbean as influenced by tillage practices and fertility levels (Mean of two years)

Treatments	Total biomass (q/ha)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Tillage practices				
Conventional	51.29	221.0	17.95	282.5
Minimum	55.53	226.7	18.88	296.3
Con.+ wheat residue	55.51	225.0	18.94	301.8
Mini.+ wheat residue	59.08	227.2	20.06	309.7
C.D. (P=0.05)	1.87	3.21	NS	3.12
Fertility levels(kg/ha				
Control	50.86	215.8	14.89	280.4
50% RDF	55.23	224.3	19.11	292.8
75% RDF	56.19	228.4	20.68	304.8
100% RDF	59.00	231.0	21.15	312.0
($N_{20}P_{40}K_{20}$)				
CD (P=0.05)	1.36	1.77	1.66	1.65
Interaction	Sig.	NS	NS	Sig.

Con. = Conventional; Mini. = Minimum; NS = Non significant; Sig. = Significant

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