Effect of different legume green manures and fertilizer doses on growth and yield of chickpea (C*icer arietinum* l.).

ABSTRACT

A field experiment was conducted at Mahanandi, Nandyal during the *rabi* season of 2021-22 to evaluate the effect of different green manure crops on the growth and yield of succeeding chickpea. Four green manure crops along with one control were grown *in situ* and incorporated into the soil before sowing of chickpea ~~crop~~ crops in respective treatments and different levels of fertilizers were applied to study their interaction effect on growth and yield attributes, nutrient uptake, and economics of succeeding chickpea. Growth attributes like plant height (40.7 & 41.2 cm), number of branches plant^{-1} (26.1 & 27.1), dry matter accumulation (3873 & 3642 kg ha^{-1}), and earlier days to 50 % flowering (53.3 & 53.8 days); grain (876 & 874.6 kg ha^{-1}), haulm (884.3 & 873.2 kg ha^{-1}) yield was found to be highest in the treatment with the incorporation of cowpea as preceding green manure and with the application of 100 % RDF. The treatment was at par with green gram and pillipesara green manuring and with the application of 75 % RDF.

Keywords: Chickpea, Cowpea, Fertilizers, Green manuring, Greengram, Pillipesara

I. Introduction

Chickpea, commonly known as gram or ~~bengal~~ Bengal gram, is an important *rabi* pulse crop cultivated in India for its economic purpose besides maintaining soil fertility. In India, chickpea is cultivated in 9.69 million hectares of area with a production of 11.07 million tonnes and with a productivity of 1142 kg ha^{-1} (*www.indiastatagri.com*, 2020-21). In Andhra Pradesh, it is cultivated in 0.45 million hectares of area with a production of 0.55 million tonnes and with a productivity of 1218 kg ha^{-1} (*www.apdes.ap.gov.in.* 2020-21).

The rampage use and complete dependence on inorganic nutrient sources to fulfill the nutritional requirements of chickpea, not only increases the cost of cultivation but also makes the soil infertile and less productive due to the absence of ~~the~~ organic matter. Hence, serious attention must be taken ~~in~~ to the nutrient management of chickpeas. The integrated application of organic manures and inorganic fertilizers maintains optimum crop yields and ~~long term~~long-term soil productivity. Legumes, as a restorative crop~~s~~, gained most of the importance as green manures due to higher biomass productivity and biological fixation leads to sustainable agriculture development Leguminous plants like greengram, cowpea, pillipesara, and horsegram are largely used for green manuring due to their biological nitrogen-fixing ability, drought tolerance, quick growth and adaptation to adverse environmental conditions.

Though chickpea is a legume that is capable of fixing atmospheric nitrogen, a proper starter dose is essential for the growth and development of the plant (Namvar *et al.*, 2011). An adequate supply of phosphorous is important for the development of roots as well as seed formation and yields ~~up the~~ soil fertility by fixing a large amount of atmospheric nitrogen through root nodules (Singh *et al.*, 2018).

Growing ~~of~~ green manure crops in ~~*kharif*~~ *Kharif* and their incorporation into the soil before sowing chickpea can ~~minimise~~ minimize the nutrient requirement of the crop and also sustains soil health and productivity. In this context, the present experiment was proposed to evaluate the effect of different green manures, ~~to~~ optimize the fertilizer dose for the enhanced yield of chickpea, and ~~to~~ study the interaction effect between green manures and fertilizers.

II. MATERIALS AND METHODS

A field experiment was carried out at the college farm of Agricultural College, Mahanandi on the "Effect of different green manure crops in minimizing the nutrient use in chickpea (*Cicer arietinum* L.)" under scare rainfall zone of Andhra Pradesh during *rabi* 2022. The experimental site was located at 15^0.51' N latitude and 78^0.61' E longitude and the soils of the experimental field ~~was~~ were sandy loam in texture, slightly alkaline in pH (7.33), low in organic carbon (0.49 %), and available nitrogen (258 kg ha^{-1}), medium in available P_2O_5 (48.3 kg ha^{-1}) and high in available K_2O (584 kg ha^{-1}). The experiment was laid out in a split-plot design and replicated three times with a plot size of 24 m^2 comprising ~~of~~ five main plots *viz.*, M_1: control (no green manure), M_2: cowpea, M_3: greengram, M_4: horsegram, M_5: Pillipesara and four sub-plots with S_1: 25 % RDF (5 kg N ha^{-1} + 12.5 kg P ha^{-1}), S_2: 50 % RDF (10 kg N ha^{-1} + 25 kg p ha^{-1}), S_3: 75 % RDF (15 kg ha^{-1} + 37.5 kg ha^{-1}) and S_4: 100 % RDF (20 kg N ha^{-1} + 50 kg P ha^{-1}). Green manure crops *viz.*, cowpea, greengram, horsegram, and pillipesara were seeded respectively during the last week of June 2021 except in the control plot. The green manures were allowed to grow up to the flowering ~~stage~~ *i.e.*, 45 DAS, and the residues were incorporated into the soil with the help of a rotovator. Proper care was taken to avoid the mixing of residues from one plot to another plot. The residues were allowed to decompose for about a month. In *rabi*, 2021-22 chickpea variety (NBeG-3) was sown on 16-10-2021 in all the treatment plots. Before sowing, fertilizer doses ~~was~~ were applied basally to the treatments as required. Both nitrogen and phosphorous ~~was~~ were applied in the form of urea and SSP basally in sub-plots as prescribed. All the recommended ~~package~~ packages of practices were followed for chickpea. ~~Pre harvest~~ Pre-harvest observations like plant height (cm), number of branches, dry matter accumulation (kg ha^{-1}), and days to flowering were recorded at regular intervals, and ~~post harvest~~ post-harvest observations like number of pods per plant, number of seeds per pod, grain, and haulm yield, harvest index was recorded after the harvest of the crop. Before sowing, the soil organic matter, soil pH, soil available nitrogen, phosphorus, and potassium were determined by using soil analysis methods (Table 1).

Comment [H1]: Please add methods of data analysis!

Table 1. Chemical properties of soil before sowing

S. No.	Particulars	Value	Method of analysis
I. Chemical characteristics			
a.	Soil pH (1:2.5 Soil water suspension)	7.33	Glass electrode pH meter (Jackson, 1973)
b.	Electrical Conductivity (dS m^{-1})	0.24	Conductivity bridge (Jackson, 1973)
b.	Organic carbon (%)	0.49	Wet digestion method (Walkley and Black, 1934)
c.	Available N (kg ha^{-1})	258	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
d.	Available P_2O_5 (kg ha^{-1})	49	Olsen's method (Olsen *et al*., 1954)
e.	Available K_2O (kg ha^{-1})	584	Flame photometry method (Jackson, 1973)

RESULTS AND DISCUSSION

Effect of Green manures

Growth parameters

Growth attributes like plant height (cm), number of branches, dry matter accumulation, and days to 50 % flowering of chickpea were significantly influenced by legume green manuring. Table 2.

Plant height

Taller plants ~~was~~ were observed with cowpea (M_2) (40.7 cm) green manuring which was at par with greengram (M_3) (39.3 cm) and pillipesara (M_5) (39.6) green manuring and differs significantly with horsegram (M_5) (38.9) green manuring. Shorter plants were observed with control (M_1) (37.1 cm).

Number of branches

Chickpea recorded more number of branches with *in situ* green manuring of cowpea (M_2) (26.1) with no significant difference between greengram (M_3) (24.4) and pillipesara(M_4) (25.9) but differs significantly with horsegram (M_5) (23.4) green manuring. ~~Significantly~~ A significantly lower number of branches were observed in control (M_1) (22).

Dry matter accumulation

Dry matter accumulation of chickpea was higher in green manuring with cowpea (M_2) (3873.3 kg ha^{-1}) which was at par with greengram (M_3) (3665 kg ha^{-1}), green manuring. Significantly lower dry matter accumulation was observed in control (M_1) (2921 kg ha^{-1}).

Days to 50 % flowering

Chickpea plants without green manuring i.e., control (M_1) (54.7) was at par with greengram (M_3) (54.1), pillipesara (M_5) (54.6), and horsegram (M_4) (54.6) green manuring and took significantly more days to 50 % flowering over cowpea (M_2). The least number of days to 50 % flowering was recorded under cowpea (M_2) (53.3) green manuring.

The predictable reasons for recording higher growth attributes in chickpea might be due to the incorporation of legume biomasses that have mobilized and enhanced the availability of macro and micro nutrients during the early stages of crop growth as reported by **Rani *et al*. (2022).** The other reason might be increased availability of growth nutrients enhanced cell division and enlargement, and photosynthesis that supported ~~for~~ a quantitative increase in growth (Panwar 2008).

YIELD ATTRIBUTES

Yield attributes like the number of pods per plant, grain and haulm yield, and harvest index ~~was~~ were significantly influenced by different green manure incorporation except for the number of seeds per pod of chickpea.

Number of pods per plant

~~Higher~~ The higher number of pods per $plant^{-1}$ of chickpea was with cowpea (M_2) (34.3) green manuring but it was comparable in green manuring with greengram (M_3) (32.7) and pillipesara (M_5) (31.9), which were found to be significant over horsegram (M_5) (30.3). Significantly, less number of pods per plant was recorded in control (M_1) (27.7).

Grain and haulm yield

Grain yield ad haulm yield of chickpea ~~were~~ was influenced significantly ~~with~~ by in situ ~~incorporation~~ incorporations of legume green manures. Higher grain and haulm yield was observed with cowpea (M_2) (876.3 & 884.3 kg ha^{-1}) as a green manure which was significantly superior over horsegram (M_4) (799.7 & 725.9 kg ha^{-1}) green manuring, but it was at par with greengram (M_3) (831.3 and 861 kg ha^{-1}) and pillipesara (M_5) (810.5 & 836.6 kg ha^{-1}) green manuring. Significantly lower yields were observed in control (M_1) (571.5 & 624.8 kg ha^{-1}).

Harvest index

~~Significantly~~ A significantly higher harvest index of chickpea was recorded with cowpea (M_2) (49.6 %) green manuring over control (M_1) (45.7 %) (without green manuring). Green manuring with greengram (M_3) (48.7 %), pillipesara (M_5) (48.0 %) was at par with

cowpea (M_2) and differs significantly with horsegram (M_4) (47.4 %) green manuring. Significantly, a lower harvest index was recorded in control (M_1) (45.7 %).

Higher yield attributes were recorded with legume green manures, this might be due to the addition of green biomass to the soil before sowing of chickpea might enhanced microbial activity in the soil which triggered the release of the unavailable form of nutrients to the available form to the soil nutrient pool thus increasing nutrient concentration in the soil that finally lead to plant uptake that enhanced plant metabolic process, enzyme activity, translocation of nutrients from source to sink with effective portioning of photosynthates to economic parts eventually led to increase in grain and haulm yield as reported by Nikita *et al*. (2015), Rani *et al.* (2022), Ramanjaneyulu *et al.* (2021).

EFFECT OF FERTILIZER LEVELS

Growth parameters

Plant height

~~Application~~ The application of 100 % RDF (S_4) (41.2 cm) recorded taller plants which was corresponding to the application of 75 % RDF (S_3) (40.2 cm) but ~~differs~~ differ significantly ~~with~~ from the 50 % RDF (S_2) application (38.6 cm). Shorter plants were observed with 25 % RDF (S_1) (36.9 cm).

Number of branches per plant

~~Significantly~~ A significantly greater number of branches per plant in chickpea were recorded with the application of 100 % RDF (S_4) (27.1) over 25 % (S_1) (21.5) and 50 % RDF (S_2) (22.9) but which was at par with 75 % of RDF (S_3) (26).

Dry matter accumulation

Application of 100 % RDF (S_4) (3642.9 kg ha^{-1}) resulted significantly high dry matter accumulation of chickpea which was near to 75 % RDF (S_3) (3483.6 kg ha^{-1}) than 25 % (M_1) (3064.9 kg ha^{-1}) and 50 % RDF (M_2) (3327.5 kg ha^{-1}). Significantly lower dry matter was accumulated in control (M_1) (3064.9 kg ha^{-1}).

Days to 50 % flowering

Days to 50 % flowering ~~was~~ decreased substantially with an increase in fertilizer levels. Significantly, earlier days to 50 % flowering was recorded with 100 % RDF (S_4) (53.8) than with 75 % (S_3) (54.2), 50 % (S_2) (54.6) and 25 % RDF (S_1) (54.6).

Growth attributes were pronounced more positively with the application of higher doses of fertilizers this might be due to improvement in the quantity of the nutrient pool of the soil. ~~Addition~~ The addition of nutrients through the inorganic source to the soil coupled with the addition of nutrients with green manure incorporation boosted the vigorous growth stature of the crop ~~that resulted~~ resulting in greater photosynthesis that eventually led to crop growth and development. Rani and Krishna (2016) reported, with the application of 40 kg N ha^{-1} ~~have~~ has increased growth parameters when compared to lower doses of fertilizer

application. The results were in conformity with the findings of Suresh Goyal et al. (2010), Neenu et al. (2014), Das et al. (2016), Nawange et al. (2018), Navya et al (2020),

Table 2: Effect of different green manures and fertilizer doses on growth attributes of chickpea

Treatments	Plant height (cm)	Number of branches	Dry matter accumulation (kg ha^{-1})	Days to 50 % flowering
Green manures (M)				
M_1 - Control	37.10	22.01	2921.07	54.75
M_2 - Cowpea	40.70	26.13	3873.32	53.33
M_3 - Greengram	39.96	24.45	3665.57	54.16
M_4 - Horsegram	38.97	23.45	3031.28	54.66
M_5 - Pillipesara	39.65	25.99	3407.43	54.66
SEm±	0.491	0.601	80.787	0.263
CD (P=0.05)	1.62	1.99	267.54	0.87
Fertilizer doses (S)				
S_1 – 25 % RDF	36.97	21.51	3064.79	54.66
S_2 – 50 % RDF	38.62	22.90	3327.55	54.66
S_3 – 75 % RDF	40.29	26.06	3483.64	54.13
S_4 – 100 % RDF	41.22	27.16	3642.96	53.80
SEm±	0.807	0.738	97.692	0.222
CD (P=0.05)	2.34	2.14	283.51	0.64
Green manures (M) x Fertilizer doses (S)				
M at S				
SEm±	1.638	1.551	205.707	0.504
CD (P=0.05)	NS	NS	NS	NS
S at M				

SEm±	0.981	1.203	161.574	0.526
CD (P=0.05)	NS	NS	NS	NS

Yield parameters

Application of higher doses of fertilizers significantly improved yield attributes of chickpea viz., the number of pods per plant, grain and haulm yield, harvest index significantly except for the number of seeds per pod in chickpea. (Table 3).

Number of pods per plant

Among different doses of fertilizer application, the application of 100 % RDF (S_4) (34.2) resulted in a significantly higher number of pods plant^{-1} which was equivalent ~~with~~ to the application of 75 % of RDF (S_3) (32.9). ~~Difference~~ The difference between 75 % RDF (S_3) (32.9) and 50 % RDF (S_2) (30.5) in producing the number of pods per plant was found to be non significant. The least number of pods plant^{-1} was recorded with 25 % RDF (S_1) (27.9).

Grain and haulm yield

Higher grain yield of chickpea was recorded with the application of 100 % RDF (S_4) (874.6 & 873.2 kg ha^{-1}) followed by the application of 75 % RDF (S_3) (830.3 & 805.1 kg ha^{-1}) which differs significantly with the application of 50 % RDF (S_2) (740.8 & 748.5 kg ha^{-1}). Significantly lower grain and haulm yield ~~was~~ recorded with the application of 25 % RDF (S_1) (665.4 & 718.5 kg ha^{-1}).

Harvest index

~~Application~~ The application of 100 % RDF (S_4) resulted in a high harvest index (49.2 %) which was at par with the application of 75 % RDF (S_3) (48.6 %) and was found to be significant with the application of 50 % RDF (S_2) (47.0 %). ~~Significantly~~ A significantly lower harvest was observed with the application of 25 % RDF (S_1) (46.8 %).

Better yield attributes of chickpea were pronounced with the application of 100 % RDF which might be due to the application of higher doses of fertilizers ~~increases~~ increasing nutrient concentration that promotes the development of all growth parameters like plant height, the number of branches, dry matter accumulation, etc., which increased economic yield of the crop. ~~Increase~~ An increase in the application of phosphorous helps in cell division, the development of root nodules, and helps in nitrogen fixation (Neenu *et al.*, 2014) which mobilized nutrients from the soil to plant and thus increased grain and straw yield in chickpea. Similar findings were reported by Devendra and Harendra (2012), Hussen *et al.* (2015), Das *et al.* (2016), Rani *et al.* (2016), and Singh *et al.* (2018),

Table 3: Effect of different green manures and fertilizer doses on yield attributes of chickpea

Treatments	Number of pods plant^{-1}	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
Green manures (M)				
M_1 - Control	27.76	571.59	624.81	45.72
M_2 - Cowpea	34.33	876.03	884.32	49.60
M_3 - Greengram	32.70	831.35	861.04	48.71
M_4 - Horsegram	30.38	799.75	725.09	47.48
M_5 - Pillipesara	31.90	810.55	836.64	48.08
SEm±	0.873	22.612	23.914	0.627
CD (P=0.05)	2.89	74.885	79.19	2.07
Fertilizer doses (S)				
S_1 – 25 % RDF	27.94	665.49	718.52	46.84
S_2 – 50 % RDF	30.50	740.87	748.57	47.02
S_3 – 75 % RDF	32.96	830.37	805.18	48.61
S_4 – 100 % RDF	34.25	874.69	873.24	49.28
SEm±	1.009	17.796	23.191	0.661
CD (P=0.05)	2.92	51.648	67.30	1.91
Green manures (M) x Fertilizer doses (S)				
M at S				
SEm±	2.140	41.218	50.879	1.425

CD (P=0.05)	NS	NS	NS	NS
S at M				
SEm±	1.746	45.224	47.828	1.254
CD (P=0.05)	NS	NS	NS	NS

Interaction effect between green manures and fertilizer doses

The interaction effect between green manures and fertilizer doses on growth and yield attributes was found to be statistically non significant.

Comment [H2]: Why??
Please add your reasons or add discussion with the references

Conclusion

Incorporation of green manures like cowpea, greengram, or pillipesara as ~~pre-green~~ pre-green manuring during ~~*kharif*~~ *Kharif* season and cultivation of chickpea in ~~*rabi*~~ *rabi* along with the application of 100 % RDF resulted in higher growth and yield attributes of chickpea on sandy loam soils of Kurnool, Andhra Pradesh. Instead of leaving land fallow green manuring with legumes protect soil from erosion and loss of nutrients and also helps in the development ~~in~~ of physical, chemical, and biological properties of the soil.

Comment [H3]: But interaction is not significant.
Please write your conclusion only from your results

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Comment [H4]: Please write this references like the guideline