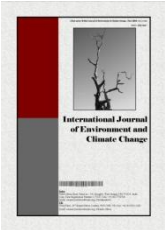

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Effect of Different Green Manuring Crops and Fertilizer Doses on Growth and Yield of Chickpea (*Cicer arietinum* L.) at Scarce Rainfall Zone of Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Mahanandi, Nandyal, Andhra Pradesh, India during the *rabi* season of 2021-22 to evaluate the effect of different green manure crops on growth and yield of succeeding chickpea. The field experiment was laid out in split-plot design with four green manure crops *viz.,* cowpea, greengram, horsegram, pillipesara along with one control were grown *in situ* and incorporated into the soil before sowing of chickpea crops in respective treatments and different levels of fertilizers *viz.,* 25 % RDF (recommended dose of fertilizer), 50 % RDF, 75 % RDF and 100 % RDF 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 and 41.2 cm), number of branches plant^{-1} (26.1 and 27.1), dry matter accumulation (3873 and 3642 kg ha^{-1}) and earlier days to 50 % flowering (53.3 and 53.8 days); grain (876 and 874.6 kg ha^{-1}), haulm (884.3 and 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 greengram and pillipesara green manuring and with the application of 75

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% RDF. Pre green manuring with cowpea and with the application of the 100 % RDF provided enhanced growth and yield parameters in chickpea than leaving the land fallow during summer season.

Keywords: Chickpea; fertilizers; Green manuring; greengram; yield attributes.

1. INTRODUCTION

Chickpea, commonly known as gram or 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}. 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}.

Chickpea is majorly cultivated rabi pulse crop in scarce rainfall zone of Andhra Pradesh where farmers apply huge quantities of fertilizers for nutritional requirement of the crop. The rampage use and complete dependence on inorganic nutrient sources to fulfil nutritional requirement of chickpea, not only increases the cost of cultivation but also makes the soil infertile and less productive due to the absence of organic matter. Hence, serious attention must be taken to the nutrient management of chickpeas. The integrated application of organic manures *i.e.,* green manures and inorganic fertilizers maintain optimum crop yields and long-term soil productivity. Legumes, as a restorative crops, 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 [1]. An adequate supply of phosphorous is important for the development of roots as well as seed formation and yields the soil fertility by fixing a large amount of atmospheric nitrogen through root nodules [2]. Growing green manure crops in *Kharif* and their incorporation into the soil before sowing chickpea can minimize the nutrient requirement of the crop and also sustains soil health and productivity. In this context, the present experiment was proposed with an objective to evaluate the effect of different green manures and fertilizer doses for the enhanced yield of chickpea, and to optimise application of fertilizer doses in chickpea.

2. 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, India 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 were sandy loam in texture, slightly alkaline in pH (7.33) by using glass electrode pH meter, low in organic carbon (0.49 %) by wet digestion method and available nitrogen (258 kg ha^{-1}) by alkaline potassium permanganate method, medium in available P_2O_5 (48.3 kg ha^{-1}) by Olsen's method and high in available K_2O (584 kg ha^{-1}) by using Flame photometry method. 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 flowering *i.e.,* 45 DAS and the residues were incorporated into the soil with the help of rotovator. Proper care was taken to avoid 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 were applied basally to the treatments as required. Both nitrogen and phosphorous were applied in the form of urea and SSP basally in sub-plots as prescribed. All the recommended packages of practices were followed for chickpea. Five plants were selected randomly from net plot and pre-harvest

observations like plant height (cm), number of branches, dry matter accumulation (kg ha^{-1}), days to flowering were recorded at regular intervals and 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.

3. RESULTS AND DISCUSSION

3.1 Effect of Green Manures

3.1.1 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 1.

3.1.1.1 Plant height (cm)

Taller plants 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).

3.1.1.2 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. A significantly lower number of branches were observed in control (M_1) (22).

3.1.1.3 Dry matter accumulation (kg ha^{-1})

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}).

3.1.1.4 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. [3]. The other reason might be increased availability of growth nutrients enhanced cell division and enlargement, and photosynthesis that supported a quantitative increase in growth [4]. Similarly, growth attributes of rice *i.e.,* plant height, no. of tillers, dry matter accumulation recorded higher with dhaincha green manuring along with the application of 100 % RDF was reported by Puli et al. [5].

3.1.2 Yield attributes

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

3.1.2.1 Number of pods per plant

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).

3.1.2.2 Grain and haulm yield (kg ha^{-1})

Grain yield ad haulm yield of chickpea was influenced significantly by *in-situ* 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}).

3.1.2.3 Harvest index (%)

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. [6], Rani et al. [3], Ramanjaneyulu et al. [7].

3.2 Effect of Fertilizer Levels

3.2.1 Growth parameters

3.2.1.1 Plant height (cm)

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 differ significantly from the application of 50 % RDF (S_2) application (38.6 cm). Shorter plants were observed with 25 % RDF (S_1) (36.9 cm).

3.2.1.2 Number of branches per plant

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).

3.2.1.3 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}).

3.2.1.4 Days to 50 % flowering

Days to 50 % flowering 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. 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 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} 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. [8], Neenu et al. [9], Das et al. [10], Nawange et al. [11], Navya et al. [12].

3.2.2 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 2).

3.2.2.1 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 to the application of 75 % of RDF (S_3) (32.9). 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).

3.2.2.2 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 recorded with the application of 25 % RDF (S_1) (665.4 & 718.5 kg ha^{-1}).

Table 1. 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

Table 2. 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

3.2.2.3 Harvest index

The application of 100 % RDF (S_4) resulted in high a 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 %). 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 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. An increase in the application of phosphorous helps in cell division, the development of root nodules and helps in nitrogen fixation [9] 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 [13], Hussen et al. [14], Das et al. [10], Rani et al. [3] and Singh et al. [2],

4. CONCLUSION

Incorporation of green manures like cowpea, greengram or pillipesara as pre-green manuring during *Kharif* season and cultivation of chickpea with the application of 100 % RDF resulted in higher growth and yield attributes of chickpea on sandy loam soils of scarce rainfall zone of 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 of physical, chemical and biological properties of the soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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