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Effect of Customized Fertilizer Application on Physiological Aspects of Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author AAA Conducted research trial, collected the data, did data analysis, interpretation of results, drafted and designed the manuscript. Authors VBJ and RRL Wrote, edited and reviewed the manuscript. Author PK critically reviewed the manuscript and served as scientific advisor. Author GPB contributed data or analysis tools, designed the experiments. Author DK critically reviewed the manuscript. Author RRS reviewed the analyzed data. All authors reviewed the results and approved the final version of the manuscript.

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Original Research Article

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ABSTRACT

It is predicted that India will required around 32 million tons of pulses to feed around 1.68 billion people by 2030. Therefore, improved technologies must be needed to increasing production. And increase in physiological efficiency of crop is important to improve the productivity and production of crop. Hence, the experiment entitled "Effect of customized fertilizer application on physiological aspects of chickpea (*Cicer arietinum* L.)" was carried out at Department of Plant Physiology, AB & MAP, College of Agriculture, IGKV, Raipur (Chhattisgarh) during *rabi* 2020-21. The experiment consists of five treatments with replicated four times in RBDS design and Indira chana 1 variety of chickpea used as a test crop. The study highlighted that that the T_5 CFG 3 (NPKSZnMo 5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (125%) was found effective to minimize the phenophase like 50% flowering, physiological maturity significantly. Higher chlorophyll value was observed in T_5 CFG 3 (NPKSZnMo 5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (125%) and Maximum Fv/Fm (chlorophyll florescence) was observed in T_4 CFG 2 (NPKSZnMo 5.5:4.6:4.5:8.3:1.4:0.034%) based on recommendation (75%). T_3 CFG 1 (NPKSZn Mo5.5: 4.6:4.5:8.3:1.4:0.034%) based on recommendation (100%) was also observed effectively increased dry matter partitioning towards the economic sink and maximize Crop growth rate, Relative growth rate, economic (seed) yield, biological yield and harvesting index. Thus, it is proved that in comparison with the recommended doses of fertilizers application of CFGA has enhanced the plant yield.

Keywords: Customized fertilizer; recommended dose of fertilizer; nutrient uptake; chickpea.

1. INTRODUCTION

The chickpea (*Cicer arietinum* L.) is a member of Fabaceae family, subfamily Faboideae. After beans and peas, chickpea is the world's third most important pulse crop**.** In 2019-20, the total production of chickpea in India was 11.08 tons with yield 1142 Kg/ha and total area 9.68 million/ha (Anonymous AICRP report 2019-20). The total production of chickpea in Chhattisgarh was 88.19 thousand tones with total area 381.77 thousand ha and yield 231 Kg/ha. Chickpea (*Cicer arietinum* L.), like other pulse crops, is a major staple food in many poor countries, and chemical fertilizers are a critical input in chickpea farming. Pulse crops like chickpea must have phosphorus and sulfur for plant development, nodule formation, and nitrogen fixation. The physiological ability of plant like photosynthetic rate (Pn) and stomatal conductance (Gs) are improved by increase in fertilizer dose of plant which ultimately improves the economical yield of plant. Chickpea crop required all organic and inorganic nutrients in appropriate amount for the growth and development of chickpea. In general, farmers apply chemical fertilizers to chickpea crop in an unbalanced and suboptimal dose because of lack of knowledge of the nutritional requirements to plant at specific area, variety and soil type. Customized fertilizer application is one of the most effective techniques to overcome this problem. Customized fertilizer is consisting of macro, secondary and/or micronutrient taken from both organic sources and inorganic sources. The Central Fertilizer Committee added customized fertilizers in the Fertilizer association of India, 1985 because it is innovative technology which made fertilizer area, soil, or crop-specific. Customized fertilizers are crop, soil, and area specific which maintains plant and soil health through suitable fertilization (Tiwari, 2010) [1]. In order to above facts the present investigation was done during *rabi* 2020-2021 on “Effect of customized fertilizer application on physiological aspects of chickpea (*Cicer arietinum* L.)” at AICRP Research Farm, IGKV, Raipur (C.G.) to find out best combination of customized fertilizer to improve performance of chickpea crop.

2. MATERIALS AND METHODS

The field experiment was performed during the *rabi* seasons of 2021-22 at the AICRP research Farm, IGKV, Raipur, Chhattisgarh. At the meteorological observatory, IGKV, Raipur, Chhattisgarh, weekly average meteorological data was recorded during the experimentation period. The total rainfall during experiment period was 29.84 mm with 9 rainy days was received during *rabi* season 2021 respectively. The

Table 1. Treatments of experiment

T_1	**Recommended level of NPK, (N: P_2O_5: K_20 20; 50; 20 kg ha^{-1})**
T_2	RDF 1 (Recommended level of NPKSZnMo20:50:20:20:25:1 kg ha^{-1})
T_3	CFG 1 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (100%) (100 kg ha^{-1})
T_4	CFG 2 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034%) based on recommendation (75%) (75 kg ha^{-1})
T_5	CFG 3 (NPKSZnMo 5.5:4.6:4.5:8.3:1.4:0.034%) based on recommendation (125%) (125 kg ha^{-1})

maximum and minimum temperatures during experiment period was 40.4oC and 10.3oC with 9 rainy days during the rabi season, respectively. The soil at AICRP research farm was clayey (Vertisols), pH 7.2 which is netural in nature, electrical conductivity (EC) 0.53 dS/m2, being low in organic carbon (0.79%), Nitorgen (235 kg ha^{-1}), Phosphorus (11.33 kg ha^{-1}) and Potassium (383.8 kg ha^{-1}). The experimental trial was laid out in a randomized block design, four replications, to evaluate the effect of a customized fertilizer (CF) on desi chickpea (*Cicer arietinum* L.). The variety Indira chana 1 was used as test crop. The data was analyzed statistically by employing analysis of variance (ANOVA) for randomized block design. Field experiments consisted of five treatments and four replications. The treatments consist of five treatments which are furnished in Table 1.

The observation recorded physiological observation like chlorophyll value, chlorophyll florescence value, CGR (crop growth rate), RGR (relative growth rate), dry matter accumulation and yield to find out better combination of customized fertilizer which response to plant growth and productivity of chickpea. The phonological traits were determined by visual observation. The chlorophyll value was taken by SPAD-502 meter by taking the mean of upper, middle, and lower leaf observations. Measurements with the SPAD-502 meter produce relative SPAD meter values that are proportional to the amount of chlorophyll present in the leaf. In order to convert these values into absolute units of chlorophyll concentration, calibration curves must be derived and utilized. Chlorophyll fluorescence analysis uses the Fv/Fm ratio as a sensitive indicator of plant photosynthetic performance. Lower values may indicate stress and/or photo-inhibition or indicate a down regulation of photosynthesis. The reading of chlorophyll fluorescence (Hansatech's Pocket PEA and Handy PEA) was taken at the 50% flowering stage, when most of the photosynthetic assimilates move toward the pod for their development and plant need more energy from photosynthesis. For dry matter accumulation traits, the sample was collected at different stages of the crop, like the vegetative stage, flowering stage, pod filling stage, and physiological maturity stage, and data was collected by taking the weight of different organs of the plant separately. The data of CGR (g m^{-2} day^{-1}) and RGR ($g^{-1}plant^{-1}$ day^{-1}) was taken by samples collected at different stages of crop and computed by using formula,

$$\text{Crop growth rate} = (w2-w1)/(p(t2-t1))$$

Where, P = Ground area, W_1 = Dry weight of plant/m^2 recorded at time t_1, W_2 = Dry weight of plant/m^2 recorded at time t_2, t_1 and t_2 were the interval of time, respectively and it is expressed in g/m^2/day.

$$\text{Relative growth rate} = (\text{In } w2 - \text{In } w1)/(t2-t1)$$

Where, In = Natural log, W_1 = Dry weight of plant/m^2 recorded at time t_1, W_2 = Dry weight of plant/m^2 recorded at time t_2, t_1 and t_2 were the interval of time, respectively and is expressed as g/g/day

The yield data was taken after harvesting and harvest index was calculated by formula,

$$\text{Harvest index} = (\text{economic yeild})/(\text{Biological yeild}) \times 100$$

The collected data on numerous growth and yield factors was tabulated first, and then statistical analysis was performed [2]. The impact of different customized fertilizer treatments was tested with the F-test. The calculated "F" value is compared with the table F value at 5% LOS. If the calculated F value was greater than the table F value, then the difference was said to be significant and a critical difference was calculated for further comparison.

3. RESULTS AND DISCUSSION

The data of physiological attributes, dry matter accumulation, and phonological attributes was recorded at different growth stages of plant *i.e*., (30DAS) vegetative stage, (60DAS) flowering stage, (90 DAS) podding stage and at harvest and reveal in Table 2 and Figs. 1, 2, and 3.

3.1 Physiological Parameters

The parameters of dry matter accumulation, chlorophyll value and chlorophyll fluorescence were furnished in Table 2 and Fig. 1, respectively.

3.1.1 Dry matter accumulation

The dry matter accumulation at early stage of crops growth was slow and it increased at later stage of crop growth up to physiological maturity of crops in all the treatments. The superior treatment for dry matter accumulation was found T_4 CFG 2 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (75%) at vegetative stage. And at flowering stage, podding stage and at harvest T_5 CFG 3 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (125%) recorded significantly higher in dry matter accumulation which is on par with T_3 CFG 1 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (100%). Dry matter accumulation in chickpea showed significant variation among all treatments because customized fertilizer contains all micro and macronutrients which are essential mineral plant nutrient that critically contribute in the process of photosynthesis and transport of photo assimilate. Similar results were obtained by Dwivedi (2010) and Meshram's [3] research paper "Response of chickpea (*Cicer arietinum* L.) to customized fertilizer under Chhattisgarh condition".

3.1.2 Chlorophyll value

Higher chlorophyll values have been observed in (50.83) T_5 CFG 3 (NPKSZnMo 5.5:4.6:4.5: 8.3:1.4:0.034%) based on recommendation (125%), which was equivalent to (50.45) T_3 CFG 1 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (100%) when compared for the control. The SPAD value was used to estimate the chlorophyll content of plant leaves. Namvar et al. [4] found that enhancing the concentration of nitrogen fertilizer in plants increased the chlorophyll content.

3.1.3 Chlorophyll fluorescence

The maximum Fv/Fm was observed in T_4 CFG 2 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (75%), while the minimum Fv/Fm was observed in T_1 RDF (recommended NPK level) (N: P2O5: K2O 20:50:20 kg ha^{-1}). Chlorophyll fluorescence can be used to determine the maximum quantum efficiency of photosystem II. Fv/Fm is a normalized ratio calculated by dividing variable fluorescence (minimum fluorescence) by maximum fluorescence. Generally, the recorded range of 0.79 to 0.84 approximates the optimal value for many plant species, with lower values indicating stress. The experimental value of 0.77 or lower might be due to observation at the flowering stage and lower irrigation.

3.1.4 Phenological parameters

According to analysis of variance there is no variation was observed significantly in various treatments of customized fertilizer combination. There was no significant variation seen in days required to germination and 50% flowering in RDF and in all combinations of customized fertilizer. The desired minimum days required to germination was observed in T_3 CFG 1 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (100%) (13.50 days) and T_1 RDF (recommended level of NPK) (N: P_2O_5: K_2O 20:50:20 kg ha^{-1}) (13.50 days). Least period required to 50% flowering was observed in T_3 CFG 1 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (100%). The additional doses of nitrogen extend the vegetative growth phase which results conversion of reproductive stage to flowering stage delayed (Rehman and Dunfu[5]. High dose of fertilizers had topmost number of days to flowering and days to maturity.

3.1.5 Yield parameters

The parameters of seed yield, stover yield and harvest index were furnished in Table 2 and Fig. 2, respectively.

3.1.6 Seed yield

Maximum seed yield was observed in T_3 CFG 1 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (100%) (1764.6 kg ha^{-1}) which was similar with T_5 CFG 3 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (125%) (1744.5 kg ha^{-1}) and

Table 2. Effect of customized fertilizer application on physiological attributes, dry matter accumulation and yield

	Dry matter accumulation										
T	**V**	**F**	**P**	**H**	**C (nmol/cm^2)**	**FV/FM**	**DTG**	**DTF (50%)**	**SY**	**STY**	**HI (%)**
T_1	0.34	3.39	12.34	14.18	30.19	0.71	13.50	57.00	1465.85	2394.21	37.98
T_2	0.26	3.03	10.74	13.21	38.63	0.70	14.50	57.50	1612.86	2584.64	38.43
T_3	0.28	3.90	17.95	15.75	50.45	0.700	13.50	56.25	1764.59	2749.11	39.11
T_4	0.37	3.35	10.04	11.23	46.73	0.77	14.25	56.75	1555.05	2484.40	38.50
T_5	0.27	4.63	18.69	17.90	50.83	0.70	14.50	57.25	1744.92	2744.50	38.84
M	0.30	3.66	13.95	14.46	43.36	0.71	14.05	56.95	1628.62	2591.37	38.04
C.D. (5%)	0.09	1.00	4.26	3.59	5.36	0.15	2.61	3.61	180.62	277.12	0.68
SE (m)±	0.03	0.32	1.38	1.16	1.74	0.05	0.84	1.17	58.62	89.93	0.22

T- Treatments, V- Vegetative stage, F-Flowering stage, P-Podding stage, H- Harrvesting, C- Chlorophyll content nmol/cm^2, FV/FM value- Chlorophyll florescence, DTG- Days to germination, DTF- Days to 50% flowering, SY- Seed yield, STY- Stover yield, HI- Harvest index

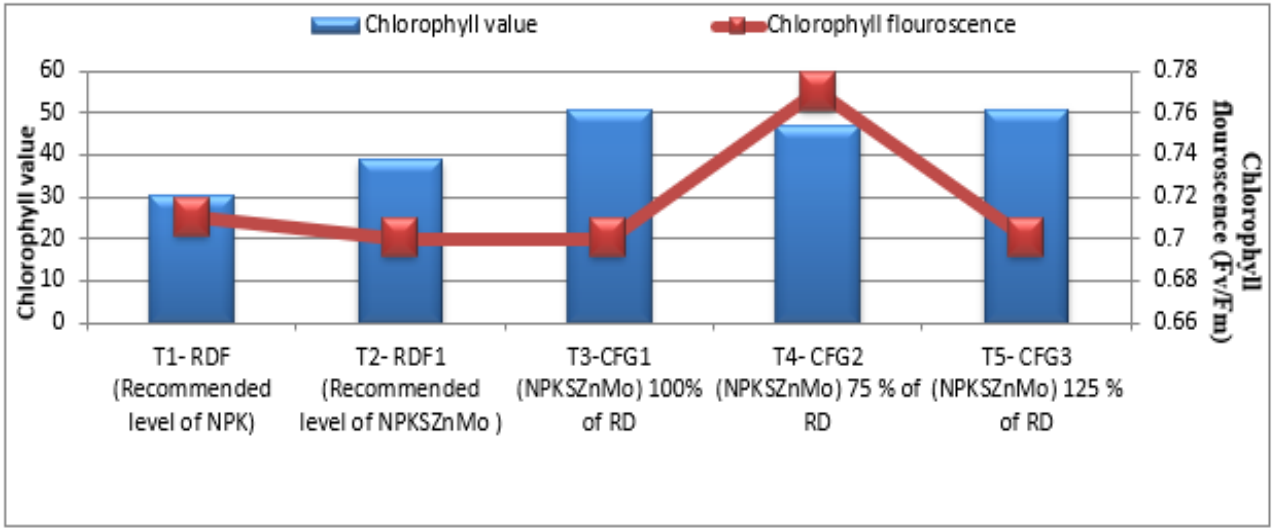

Fig. 1. Chlorophyll content unit

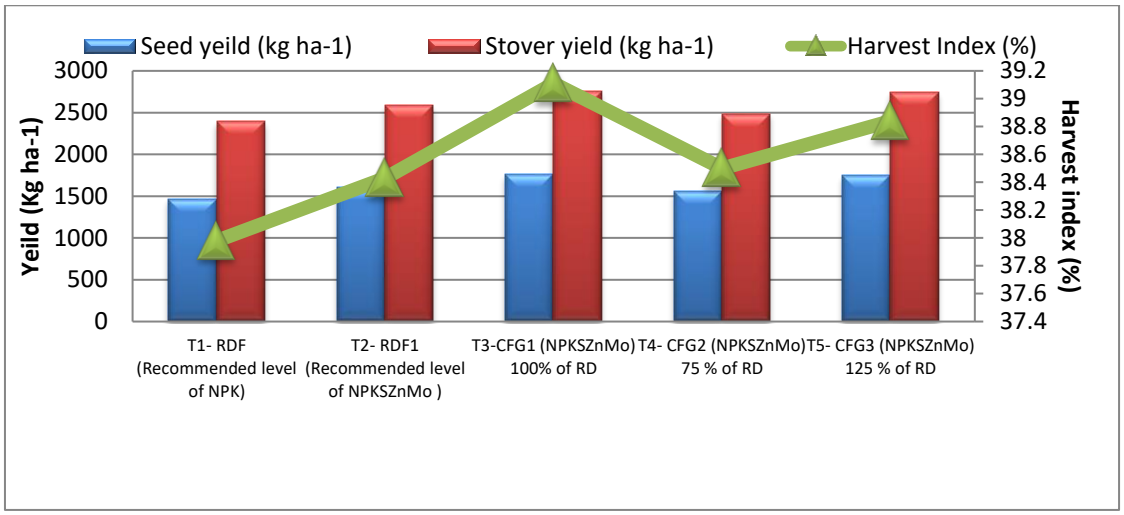

Fig. 2. Yield and harvest index

minimum seed yield T_1 RDF (recommended level of NPK) (N: P_2O_5: K_2O 20:50:20 kg ha^{-1}) (1465.85 kg ha^{-1}). Sekhon et al. [6] observed that different concentrations of customized fertilizer boosted wheat seed production considerably. This was because the crop not experiences any nutrient stress at any growth phase because of balanced nutrition and also enhanced vegetative development as well as growth parameters like number of branches and total dry matter production increased, which resulted in a good grain yield. Kavalappa [7] reported comparable findings.

3.1.7 Stover yield

The highest stover yield obtained in T_3 CFG 1 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034%) based on recommendation (100%) (2749.1 kg ha^{-1}) is on par with (2744.50 kg ha^{-1}) T_5 CFG 3 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (125%) as compared to other treatments. The best possible yield and biomass have been obtained through the effective use of NPK, S, and Zn. Increases in vegetative growth, such as plant height, dry matter production, straw yield, and branch count, could be the cause of the biomass increase.

3.1.8 Harvest index

Harvest index is significant parameter for calculating the yield performance *via.* obtaining biological and economic yield. The maximum harvest index was obtained in T_3 CFG 1 (NPKSZnMo) based on recommendation (100%) (39.11%) and minimum results obtained in (37.98%) T_1 RDF 1 (Recommended level of NPKSZnMo) (N: P_2O_5: K_2O 20:50:20 kg ha^{-1}). This results are accordance with Dwivedi et al. [8].

3.2 Growth Analysis Parameters

The data on growth analysis *i.e.*, RGR, CGR and AGR were derived by using whole plant weight at 0-30 DAS (Vegetative stage), 30-60 DAS (flowering stage), 60-90 DAS (Podding stage) and 90- at harvest. It was found that these traits were affected by different combination of customized fertilizer and furnished in Table 3 and Figs. 3 and 4.

3.2.1 Crop growth rate (g^{-1} m^{-2} day^{-1})

The CGRs data reveals that non-significant variation observed at 0-30 DAS and 90 DAS-harvest but significant variation was observed in 30-60 and 60-90 DAS, respectively. The highest CGR rate was observed in 60-90 DAS after that it slowed down.T_5 CFG 3(NPKSZn Mo5.5:4.6:4.5:8.3:1.4:0.034%) based on recommendation (125%) was observed to be most effective in improving crop growth rate in between vegetative to reproductive phase *i.e.*, 30-60, 60-90 and 90-harvest.

CGR is most important analysis to check rate of photosynthesis, rate of respiration and canopy area interaction [9]. From lower value, CGR reach at certain peak and later decline in last stage of growth of crop [10]. Crop growth rate is the amount of biomass gained by a crop over a period of time. At the start of the crop, the CGR was slow. At 60-90 DAS, the maximum CGR was

recorded, followed by a decreasing trend at 90 DAS- harvesting at the harvest stage of crops, whereas at 0-30 DAS CGR was less then start increasing at 30-60.This suggests that the vegetative stage of the crop takes longer to collect dry matter as well as to translocate biomass from source to sink's than the reproductive stage.

3.2.2 Relative growth rate ($g^{-1}plant^{-1}$ day^{-1})

(RGR) Relative growth rate was observed significantly highest at 30-60 DAS. The RGR increased in T_3 CFG 1 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034%) based on recommendation (100%) (0.00792 g $plant^{-1}$ day^{-1}) was at par T_5 CFG 3 (NPKSZnMo5.5:4.6:4.5:8.3:1.4:0.034%) based on recommendation (125%) (0.003106 g $plant^{-1}$ day^{-1}) as compared to other treatments, whereas, at 90- harvesting days RGR was higher in T_3 CFG 1 (NPKSZnMo5.5:4.6:4 .5:8.3:1.4:0 .034%) based on recommendation (100%) (0.02493) as compared to T_1 RDF (Recommended level of NPK) (N: P_2O_5: K_2O 20:50:20 kg ha^{-1}). The increase in RGR was registered rise in the levels of nitrogen and phosphorus.

RGR was high in the initial phase of the crop's growth and gradually declined when it grew older. This could be because the ratio between alive and dead tissues is high in the early stages of plant growth, and almost entire cells of productive organs are active in vegetative matter production, resulting in a high RGR of plants, However, as plants get older, their tissues' metabolic process of cell progressively reduced and they are unable to support the growth that leads to a drop in RGR [9,11-14]. Likewise, according to Yasari and Patwardhan [1], a lower NAR could lead to a lower RGR in the future.

Table 3. Effect of customized fertilizer application on Crop growth rate and Relative growth rate of crop

T	0-30 DAS	30-60 DAS	60-90 DAS	90-at harvest	0-30 DAS	30-60 DAS	60-90 DAS	90-at harvest
	Crop growth rate (CGR)				Relative growth rate (RGR)			
T_1	0.9450	3.1880	3.7250	3.2830	0.01003	0.10598	0.26085	0.16688
T_2	0.9530	3.4980	4.2130	3.6000	0.00858	0.05540	0.31508	0.14720
T_3	1.0745	4.0000	5.0700	4.3530	0.01045	0.10944	0.46905	0.20000
T_4	1.0630	3.3430	4.3280	3.7700	0.01208	0.09929	0.31606	0.19170
T_5	1.2900	4.9950	5.9250	4.6180	0.00850	0.14520	0.53130	0. 20100
M	1.0652	3.8048	4.6522	3.9248	0.00990	0.10300	0.37840	0.18100
C.D. (5%)	N/A	1.2520	1.3580	N/A	0.00200	0.02930	0.11700	0.05500
SE (m)±	0.1000	0.4020	0.4360	0.4130	0.00100	0.01340	0.05410	0.02500

T- Treatments, DAS- Days after sowing

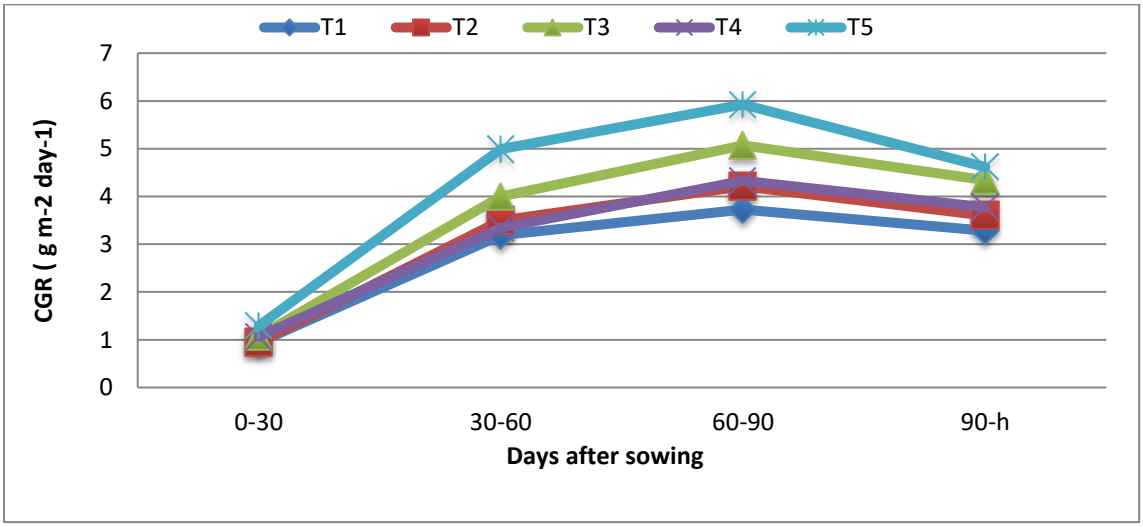

Fig. 3. Crop growth rate

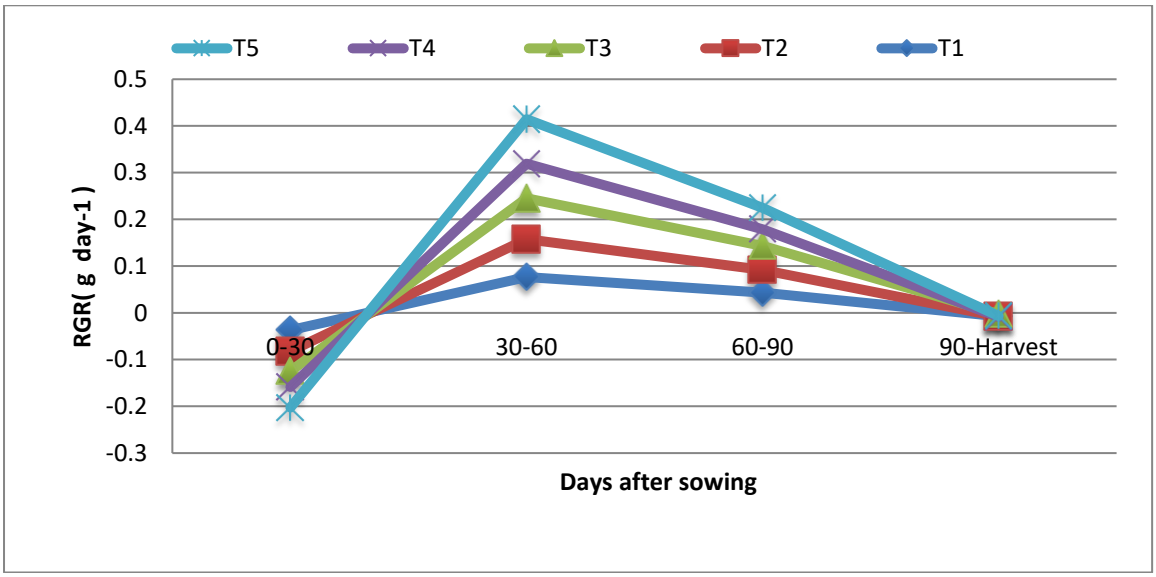

Fig. 4. Relative growth rate

4. CONCLUSION

The customized fertilizer application was most effective to improving the physiological efficiency of crop to improve the yield of chickpea. The customized fertilizer contain mixture of different micro and macronutrients with recommended dose which was efficient towards performance to dry matter partitioning and transport assimilates to source and sink to achieve maximum economic (seed) yield. It is reveal that the physiological treads such as chlorophyll unit, chlorophyll florescence, dry matter accumulation, growth analysis parameters such as CGR and RGR was found to be most effective in treatment T_5 CFG 3 (NPKSZnMo 5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (125%) but T_3 CFG 1 (NPKSZnMo 5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (100%) found to be most effective for production and efficient partitioning, this treatment is beneficial economically as compare to T_5 CFG 3 (NPKSZnMo 5.5:4.6:4.5:8.3:1.4:0.034 %) based on recommendation (125%) and other treatments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Arti Manohar Ambhore, Vaibhav Baburao Jadhav, Rajendra Ramesh Lipane, Dr. Pratibha Katiyar, Dr. G. P. Banjara, Dr. Dharmendra Khokhar and Dr. R. R. Saxena hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Arti Manohar Ambhore, Vaibhav Baburao Jadhav, Rajendra Ramesh Lipane, Dr. Pratibha Katiyar, Dr. G. P. Banjara, Dr. Dharmendra Khokhar and Dr. R. R. Saxena have declared that no competing interests exist.

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