

EFFECT OF ORGANIC AND INORGANIC FERTILIZER DOSES ON YIELD AND YIELD COMPONENTS OF COMMON BEANS

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ABSTRACT

An experiment was carried out at the Dicle University, Agriculture Faculty, southeast Anatolia of Turkey during the years 2020 and 2021. The study was conducted to determine the effect of chicken manure levels (2.0 and 3.0 t ha⁻¹), nitrogen and phosphorus levels (40:60, 40:80 and 40:100 kg ha⁻¹) and their combinations (chicken manure levels + NP levels) on the growth, yield and yield components of common beans (*Phaseolus vulgaris* L.) The experiment was laid out in a randomized complete block design with three replications. Fertilizers on the soil surface were applied at sowing time. Dry biomass, dry stem weight, dry leaf weight and leaf area were investigated at 15 days intervals starting from 20 days after the emerging (DAE) until 80 DAE. Seed yield and yield components were evaluated at the maturity time. The effect of fertilizer treatments on growth, yield and yield components was significant, and fertilizer treatments increased the growth, yield and yield components compared to the control. The highest dry biomass, dry stem weight, dry leaf weight and leaf area values were observed when chicken manure 3 t ha⁻¹ + 40N + 100P kg ha⁻¹ at 65 DAE was applied. The highest seed yield, number of primary and secondary branches and pod weight plant⁻¹ were observed at the application of chicken manure 2 t ha⁻¹ + 40N + 60P kg ha⁻¹ combination. Seed yield ranged from 1521.5 kg ha⁻¹ in control plots to 2742.1 kg ha⁻¹ in chicken 2 t ha⁻¹ + 40N + 100P kg ha⁻¹. Therefore, adding chicken manure (2 t ha⁻¹) and chemical fertilizers (40N + 100P kg ha⁻¹) combinations to nutrient management systems was deduced more efficient than chemical fertilizer or chicken manure alone treatments on growth and yield of common bean.

Keywords: Chicken manure, Common bean, Chemical fertilizer, Turkiye, Yield, Yield components

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INTRODUCTION

Common bean (*Phaseolus vulgaris*) is a common legume consumed as a staple food by humans worldwide due to its high protein, phosphorus, iron, vitamin B1, fiber and free of cholesterol (Hernández *et al.* 2007; Ntatsi *et al.* 2018). It is characterized by its high nitrogen fixation capacity by rhizobia species. The crop-rhizobia symbiosis is often sub-optimal, and the common bean demonstrates a low biologic nitrogen fixation capacity relative to more modern leguminous crops. The nitrogen fixation capacity of the common bean is affected by climatic and edaphic conditions and genotypes. Ennie and Kemp (1981) reported that the nitrogen fixation abilities of common beans differed under different temperature regimes, and early June seedlings fixed more nitrogen than mid-May ones when grown for the same growth period. Similarly, rhizobia activity on bean crops is low in our land areas due to hot and dry weather. Also, studies showed that nitrogen fixation capacity varied

between gene pools (Middle American and Andean) and genotypes, and the need to develop varieties with a greater biological nitrogen fixation capacity should be the target of breeding programs (Ramaekers 2011, Wilker *et al.* 2019). However, yield and yield components are the characters that are under the influence of genotype, environment and agronomic practices and often agricultural management can compensate for these deficiencies of genotypes. Castro-Guerrero *et al.* (2016) reported that developing common bean varieties able to thrive under nutrient-limiting conditions will have a major impact on human nutrition, particularly in countries where dry beans are the main source of carbohydrates, protein and minerals. However, the applications of synthetic nitrogen and phosphorus fertilizers to the common bean are widespread to improve yield and yield quality. This could help ensure meet the rising demand for this crop (Martínez-Romero 2003; Hussain 2017). Phosphorus treatment on bean plants is positively affected on yield, shoot dry matter and number of pods (Fageria and Baliga 2016). Muller and Pereira

(1995) reported that nitrate added plants showed a significantly higher dry mass, specific leaf area and leaf expansion than ammonium nitrate supplied plants (Brück and Guo, 2006).

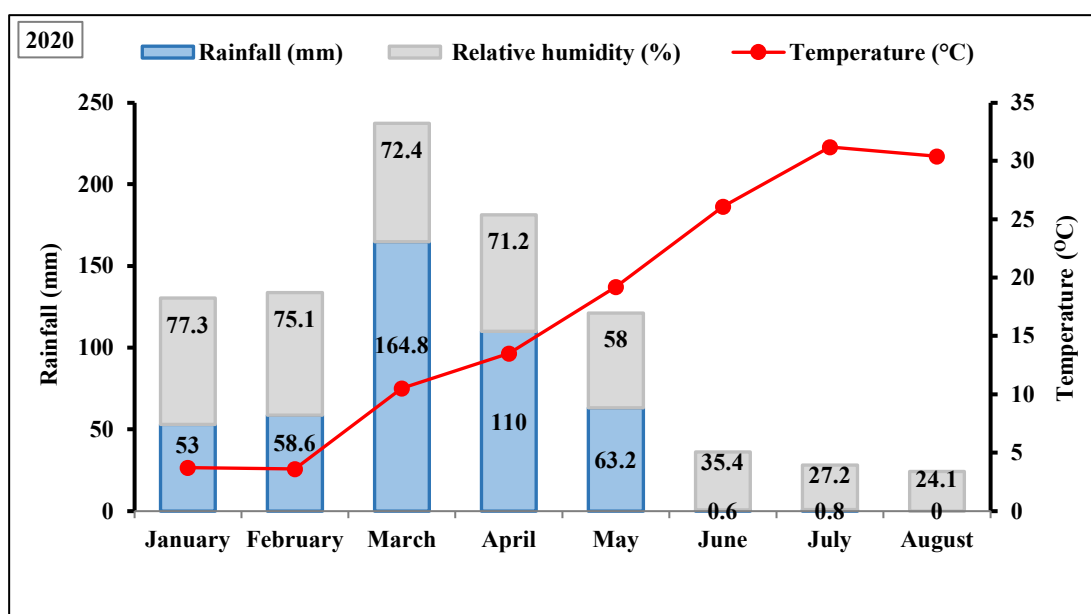
The effect of inorganic nitrogen and phosphorus fertilizers are indisputable compared to organic fertilizers on the growth and development of dry beans. Organic fertilizers can be used as the best alternative to chemical fertilizers. The equilibrium of organic and inorganic fertilizer use is the key to handling the soil nutrients properly which is due to the organic and inorganic fertilizers contributed many advantages of each (Triwulaningrum 2009). Researchers reported that the combination of organic and mineral fertilizers are positive interaction (Bodruzzaman *et al.* 2010; Ucar 2019). Chicken manure is efficient as a fertilizer for total nitrogen and had an appreciable residual effect, and grain yield, grain quality and straw yield were advanced by the rate of chicken manure (Tagoe *et al.* 2010; Sitinjak and Purba 2018; Ucar and Erman 2020). Sachan and Krishna (2021) reported that organic and inorganic fertilizers combinations significantly increased the growth and green pod yield of French bean. Treatment of inorganic fertilizer is a faster way to preserve the productivity of crop because the nutrients are easily releasing nutrients (e.g. NPK nutrients) which is needed to plants. Meanwhile, organic matter may be formed of manure organic (cow manure, green manure) able to improve the physical, chemical, and biological soil (Santosa *et al.* 2017). The use of chemical fertilizer lonely increases the crop yield in the initial years but after that adversely affects sustainability. However, it is very difficult to recover the damage chemical fertilizers cause to the soil,

environment and the living ecosystem. Even though organic fertilizers cannot contribute to the yield as much as inorganic fertilizers, because they improve the physical, chemical and biological properties of the soil, it is very important for the sustainability of agricultural production to be given with chemical fertilizers or alone.

Organic fertilizers are dissolved and absorbed slowly compared to chemical fertilizers (Shaji *et al.* 2021). Chicken manure among organic fertilizers contains high concentrations of potassium and phosphorus (Pinto *et al.* 2012), is the concentrated basis of nutrition elements for improving crop growth. The adequate use of chicken manure can improve the growth of legumes compared to inorganic fertilizers. The objective of the present work was to compare the effect of chicken manure levels as organic fertilizer, nitrogen and phosphorus levels as chemical fertilizer applied alone and their combinations on the growth, yield and yield components of common beans.

MATERIALS AND METHODS

Study sites: The study was carried out during the years 2020 and 2021 at the Dicle University, Agriculture Faculty Diyarbakır, 37° 56' 23" N and 40° 15' 12" E southeastern Anatolia of Türkiye. Rainfall was received from the April and May in 2020 total 175 mm, but none was received in 2021 growing season. Average temperatures from April to August were 26.5°C to 31.5°C. Relative humidity was very low about 12-15% (Figure 1).



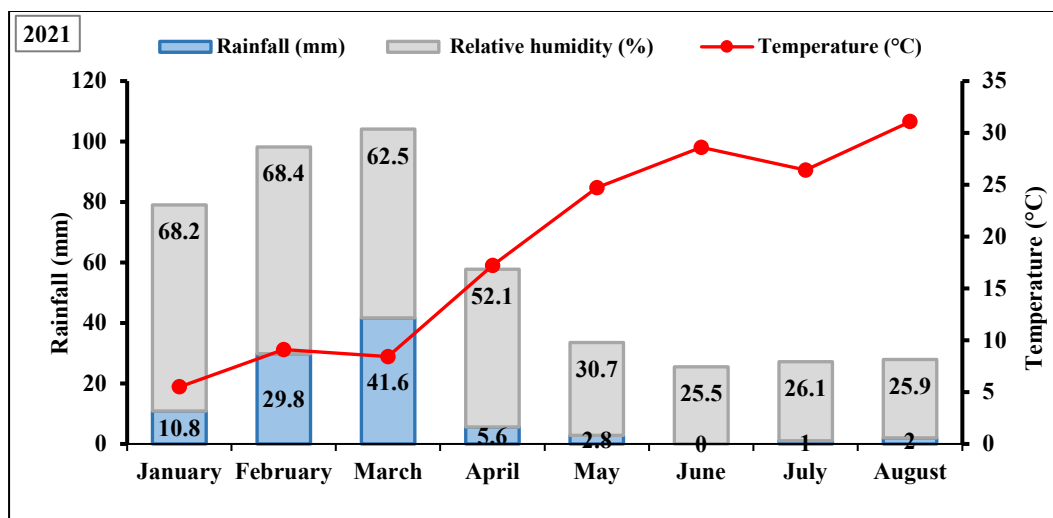


Figure 1. Monthly rainfall, temperature and relative humidity from January to August during 2020 and 2021 experimental period in Diyarbakir (Anonymous)

Soil was clay (72.6%) in texture and low contained low organic matters (0.64%). P_2O_5 and K_2O in the soil were very low (18.8 kg ha^{-1}) and high ($1363.2 \text{ kg ha}^{-1}$) respectively. The experimental site is characterized by deep, well-drained loam soil and a semi-arid climate (humid winters and dry summers). The seedbed preparation included disc harrow tillage at 15-20 cm depth in October, and cultivator at 10-15 cm and planking three days before seeding.

Trial establishment: Common bean variety, Aras was used as material and its growth habit type II is an erect indeterminate bush. The seeds were sown (25 seeds m^2) on April 22 during both years. Fertilization was applied at sowing. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4 m row length and 4 rows, row spacing 0,5 m. Plots and blocks were separated by 1.0 m and 2.0 m, respectively. The plots were irrigated twice a week in a total 500 mm of irrigation water after emerging. Spudding was carried out twice in order to fight weeds and to provide aeration of the soil in the first development period of the crops.

Urea (46% N) and triple superphosphate (46% P) was used as a source of N, P. Chicken manure (CM) supplied from the Department of Animal Science at Dicle University Faculty of Agriculture consisted of organic matter 58%, total nitrogen 4.09% and phosphorus content 0.3%. Studied nitrogen, phosphorus, chicken manure fertilizers and their combinations rates were applied as $40N+60P \text{ kg ha}^{-1}$ (NP1), $40N+80P \text{ kg ha}^{-1}$ (NP2), $40N+100P \text{ kg ha}^{-1}$ (NP3), 2 t ha^{-1} (CM1), 3 t ha^{-1} (CM2), 2 t $ha^{-1}+40N+60P$ (CM1+NP1), 2 t $ha^{-1}+40N+80P$ (CM1+NP2), 2 t $ha^{-1}+40N+100P$ (CM1+NP3), 3 t $ha^{-1}+40N+60P$ (CM2+NP1), 3 t $ha^{-1}+40N+80P$ (CM2+NP2) and 3 t $ha^{-1}+40N+100P$ (CM2+NP3).

Measurements: Plant samples were collected at 15day intervals starting from 20 days after the emerging (DAE) until 80 DAE. The above-ground plant parts were segmented into components as plant biomass, leaves, stem and pods. The plant parts were dried in an oven at 70°C for 72 hours and weighed. An HP Scanjet 3400C measured leaf area in Winfolia software immediately after sampling. Spectral characteristics of leaves of common bean plants at the flowering stage in different treatment plots were measured using a Green Seeker optical sensor. SPAD value was measured by using the SPAD 502 Chlorophyll-Meter at 50% flowering time.

Leaf color was measured by Konica Minolta (2007). $L^*a^*b^*$ color systems were used in the study. In these color systems, these letters represent (Konica Minolta 2007): L^* : Lightness (0: black, 100: white) a^* : Greenness and redness (-60: green, +60: red) b^* : Blueness and yellowness (-60: blue, +60: yellow).

The ten plants were harvested at maturity time for seed yield components. Plots were harvested on 30 August. The harvested plot area for seed yield was 3.0 m^2 .

Data analysis: Recorded data were statistically analyzed by applying the analysis of variance technique (Gomez and Gomez 1984). Duncan Real Difference Test (0.05) by Jump-Pro13 statistical software was used for the mean grouping of the treatments.

RESULTS AND DISCUSSION

Differences among years were not significant, thus the combined results of both years were given. Dry biomass and dry stem weight were significantly affected by both alone (chicken or chemical) and combined fertilizer (chicken + chemical fertilizer) applications.

Combined applications were more effective than control and alone (chicken or chemical) fertilizer treatments. Dry biomass and dry stem weight values were lower than 5.0 g on the 20th day. They were higher than 6.0 g only in CM2+NP2 and CM2+NP3 combination treatments on the 35th day. Dry biomass values rose sharply until the 65th day, but they decreased after the 65th day. Dry biomass and dry stem weight increased in CM2+NP3 fertilizer

combinations on the 65th day. Fertilizer treatments significantly increased dry biomass and dry stem weight compared to control on 50 and 80th days, while there was no significant difference between control and NP2 treatment at these growth stages (Figure 2, 3). Browaldh (1992) reported that compost and chicken manure treatments significantly increased the shoot dry weight as compared to the control and TSP.

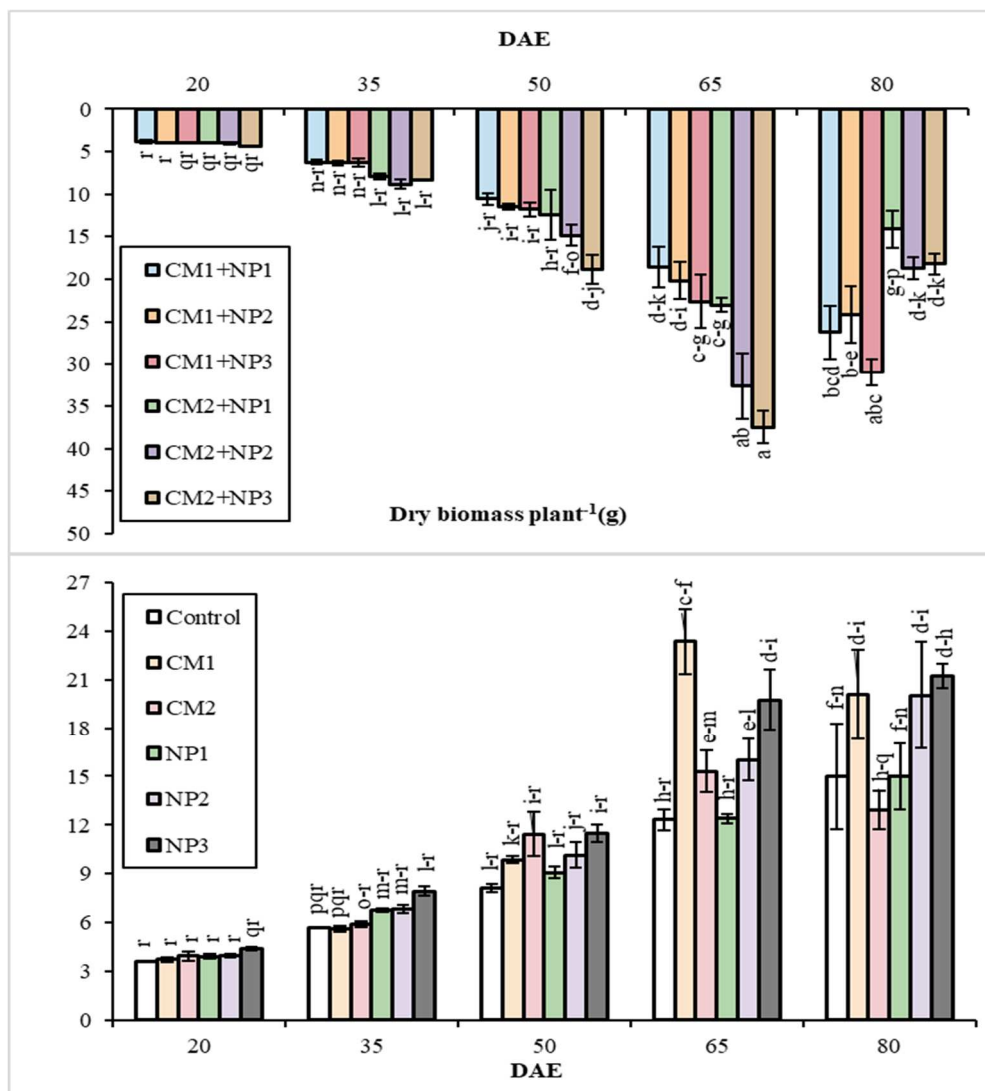


Figure 2. Dry biomass (g plant⁻¹) under chicken manure and chemical fertilizer

Here, 40N+60P kg ha⁻¹ = (NP1), 40N+80P kg ha⁻¹ = (NP2), 40N+100P kg ha⁻¹ = (NP3), 2 t Chicken Manure ha⁻¹ = (CM1), 3 t Chicken Manure ha⁻¹ = (CM2), 2 t Chicken Manure ha⁻¹+40N+60P = (CM1+NP1), 2 t Chicken Manure ha⁻¹+40N+80P = (CM1+NP2), 2 t Chicken Manure ha⁻¹+40N+100P = (CM1+NP3), 3 t Chicken Manure ha⁻¹+40N+60P = (CM2+NP1), 3 t Chicken Manure ha⁻¹+40N+80P = (CM2+NP2) and 3 t Chicken Manure ha⁻¹+40N+100P = (CM2+NP3).

Means shown with the same letters are not significantly different

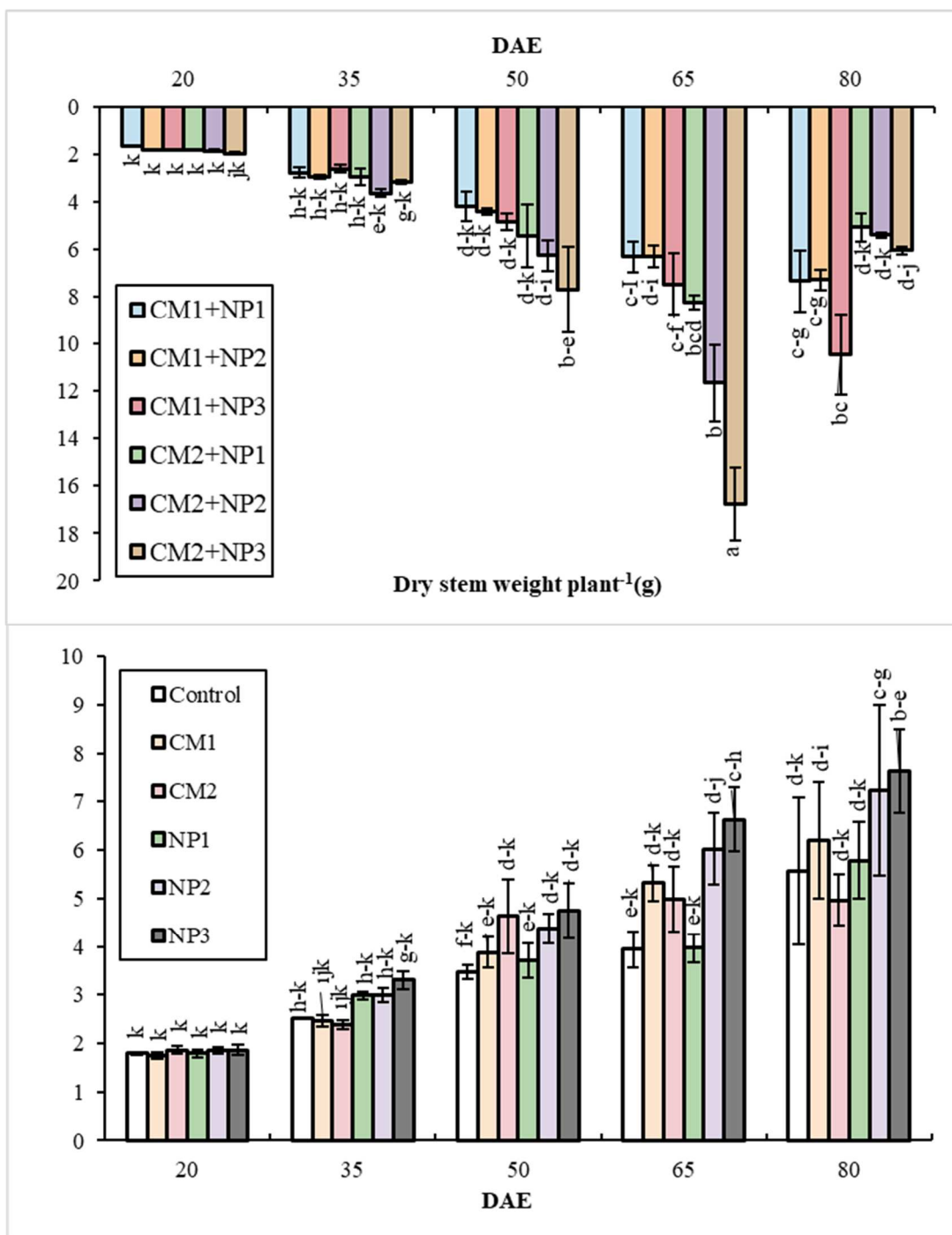


Figure 3. Dry stem weight (g plant⁻¹) under chicken manure and chemical fertilizer

Here, 40N+60P kg ha⁻¹ = (NP1), 40N+80P kg ha⁻¹ = (NP2), 40N+100P kg ha⁻¹ = (NP3), 2 t Chicken Manure ha⁻¹ = (CM1), 3 t Chicken Manure ha⁻¹ = (CM2), 2 t Chicken Manure ha⁻¹+40N+60P = (CM1+NP1), 2 t Chicken Manure ha⁻¹+40N+80P = (CM1+NP2), 2 t Chicken Manure ha⁻¹+40N+100P = (CM1+NP3), 3 t Chicken Manure ha⁻¹+40N+60P = (CM2+NP1), 3 t Chicken Manure ha⁻¹+40N+80P = (CM2+NP2) and 3 t Chicken Manure ha⁻¹+40N+100P = (CM2+NP3).

Means shown with the same letters are not significantly different

Dry leaf weight was lower than 2.0 g, and there was no significant difference between control and other

treatments on the 20th day. Differences between control and treatments for the leaf area were significant on the

20th day. Dry leaf weight and leaf area increased until 35th day, and reached maximum values up till the 65th day. Fertilizer treatments significantly increased dry leaf weight and leaf area compared to control at 50th and 80th days, but there was no significant difference between control and NP1 treatment at these growth stages. The highest values on the 50th and 65th days were in CM2 + NP2 and CM2+NP3 combinations, also the lowest dry leaf weight and leaf area were in CM2+NP1 treatment on the 80th day (Figure 4, 6). It was observed that dry leaf weight and leaf area increased as chicken manure and

chemical fertilizer levels increased in this study. Alhroutet *et al.* (2016) noted that NPK, chicken manure and their combinations were significantly affected the number of leaves per plant and plant height. However, Shaheen *et al.* (2018) reported that chicken manure tea, NPK and effective micro-organism treatments did not affected the number of leaves and branches per plant. Tekin and Biçer (2022a), reported that application of vermicompost on the soil was high results in pod traits, length, number and weight, leaf area, number of leaves, leaf and stem dry weight.

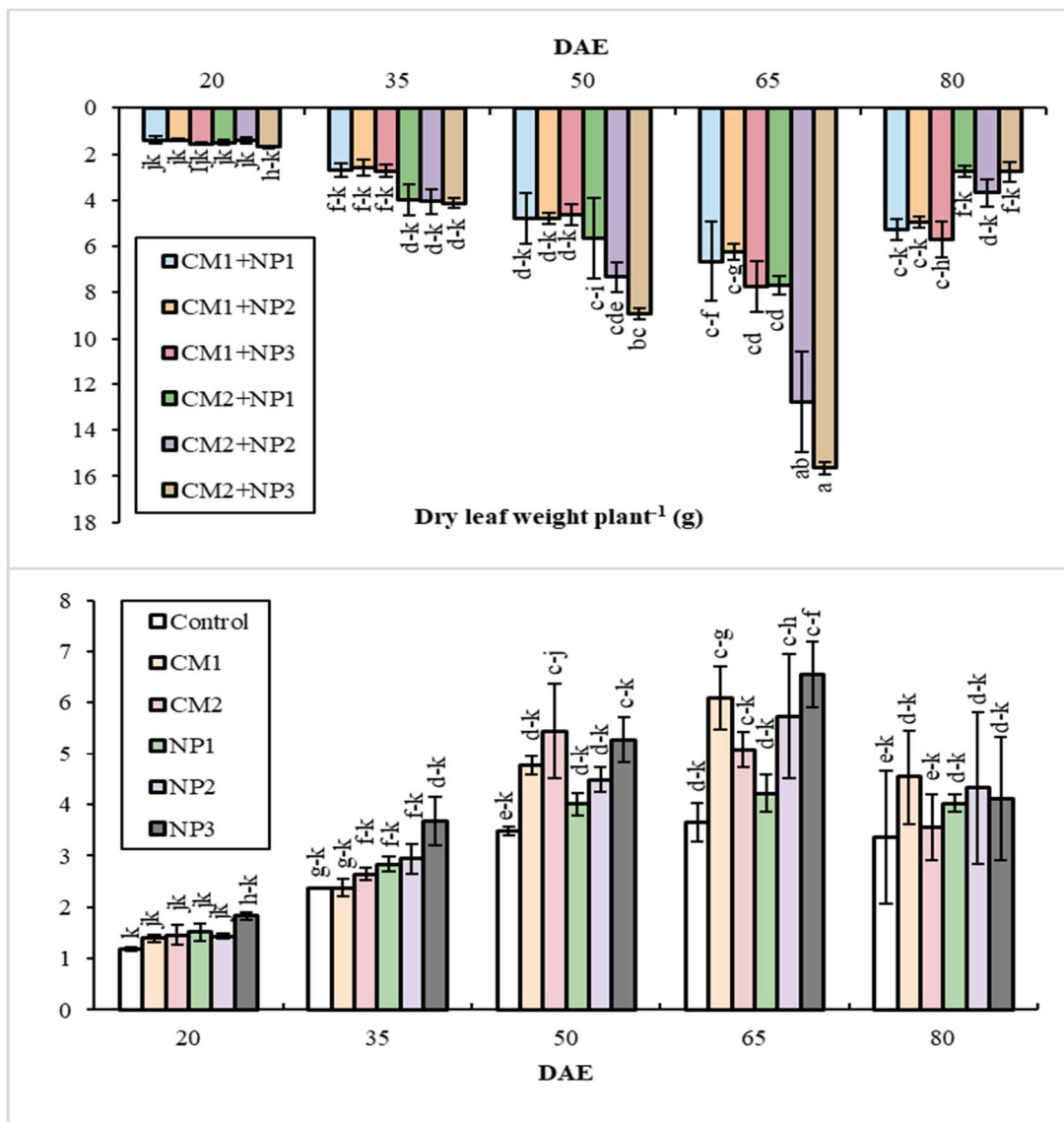


Figure 4. Dry leaf weight (g plant⁻¹) under chicken manure and chemical fertilizer

Here, 40N+60P kg ha⁻¹ = (NP1), 40N+80P kg ha⁻¹ = (NP2), 40N+100P kg ha⁻¹ = (NP3), 2 t Chicken Manure ha⁻¹ = (CM1), 3 t Chicken Manure ha⁻¹ = (CM2), 2 t Chicken Manure ha⁻¹+40N+60P = (CM1+NP1), 2 t Chicken Manure ha⁻¹+40N+80P = (CM1+NP2), 2 t Chicken Manure ha⁻¹+40N+100P = (CM1+NP3), 3 t Chicken Manure ha⁻¹+40N+60P = (CM2+NP1), 3 t Chicken Manure ha⁻¹+40N+80P = (CM2+NP2) and 3 t Chicken Manure ha⁻¹+40N+100P = (CM2+NP3).

Means shown with the same letters are not significantly different

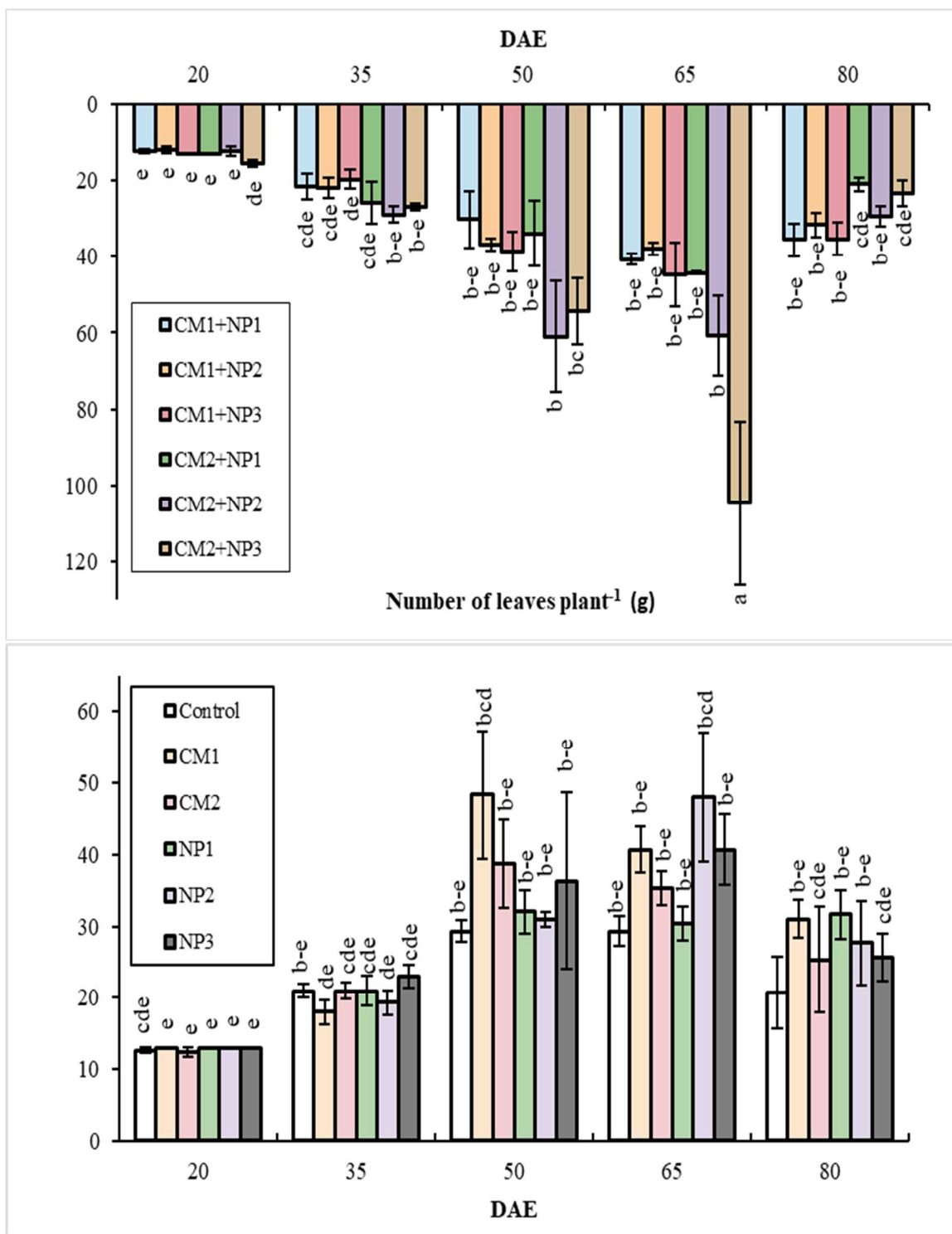
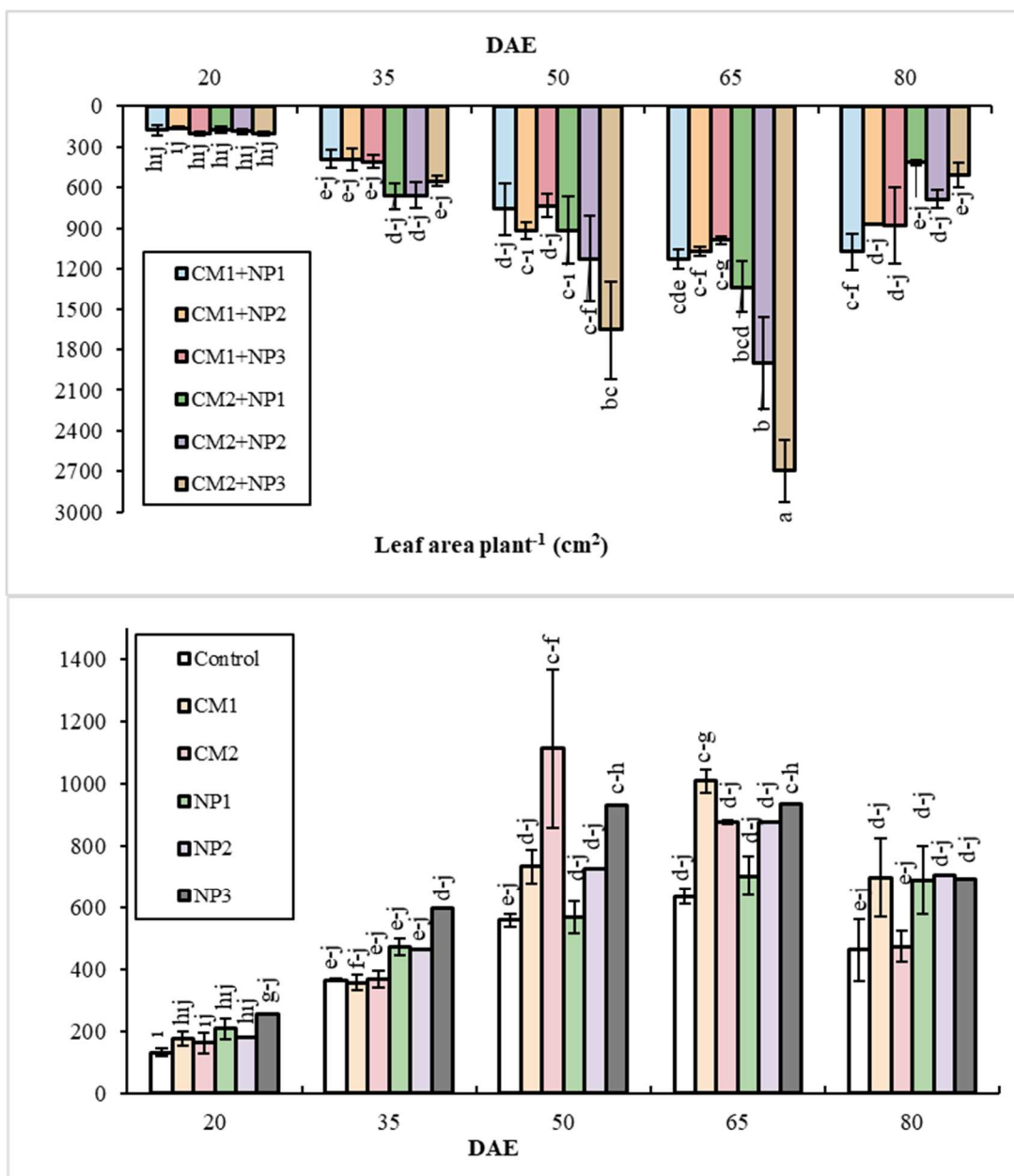


Figure 5. Number of leaves (g plant⁻¹) under chicken manure and chemical fertilizer

Here, 40N+60P kg ha⁻¹ = (NP1), 40N+80P kg ha⁻¹ = (NP2), 40N+100P kg ha⁻¹ = (NP3), 2 t Chicken Manure ha⁻¹ = (CM1), 3 t Chicken Manure ha⁻¹ = (CM2), 2 t Chicken Manure ha⁻¹+40N+60P = (CM1+NP1), 2 t Chicken Manure ha⁻¹+40N+80P = (CM1+NP2), 2 t Chicken Manure ha⁻¹+40N+100P = (CM1+NP3), 3 t Chicken Manure ha⁻¹+40N+60P = (CM2+NP1), 3 t Chicken Manure ha⁻¹+40N+80P = (CM2+NP2) and 3 t Chicken Manure ha⁻¹+40N+100P = (CM2+NP3).

Means shown with the same letters are not significantly different



Chicken manure and chemical fertilizer treatments were statistically significant for all yield and yield components during both years. Differences among years were not significant, thus the combined results of both years were given (Table 1). Yield components increased in all treatments compared to the control. The highest plant biomass, seed yield, number of primary and

secondary branches, pod weight plant^{-1} and number of seeds pod^{-1} were observed from the CM1+NP1 combination, except for plant height (Table 1).

The highest plant height value was observed from CM2+NP1 combination, which resulted in increases of 28.8% relative to the control. The lowest increase was in NP1 with 3.6%. Seed yield plant^{-1} , the number of

secondary branches plant⁻¹ and pod weight plant⁻¹ were increased by about 73%, 90% and 80% respectively, in CM1+NP1 treatment compared to control (Table 1).

Treatment of alone chicken manure compared to NP and chicken manure combinations was not increased

yield components. Similarly, CM1+NP3 and CM2+NP3 were not influence as much as their other combinations. In addition, CM2+NP3 combination was significantly negative affected to yield components such as plant biomass, plant height and seed yield plant⁻¹(Table 1).

Table 1.Yield components under chicken manure and chemical fertilizer

Treatments	Plant Height (cm)	Biomass plant ⁻¹ (g)	Seed yield plant ⁻¹ (g)	No of primary branches plant ⁻¹	No of secondary branches plant ⁻¹	Pod weight plant ⁻¹	Number of seeds pod ⁻¹	Harvest index (%)
Control	30.2 f	25.1 d	9.6 f	2.0 e	4.1 c	14.6 c	3.1 b	44 ab
NP1	31.3 ef	30.3 bcd	13.0 cde	2.7 cde	5.7 bc	20.1 b	3.6 ab	38 ab
NP2	34.8 b-f	34.1 ab	13.3 bcde	3.3 a-d	6.7 ab	22.1 ab	4.1 a	36 b
NP3	34.1 c-e	35.1 ab	15.2 abc	4.0 a	6.7 ab	22.4 ab	4.1 a	35 b
CM1	34.1 c-e	28.8 cd	11.7 def	2.6 de	6.4 ab	19.9 b	3.5 ab	34 b
CM1+NP1	37.8 ab	39.0 a	16.6 a	4.1 a	7.8 a	26.3 a	4.1 a	38 ab
CM1+NP2	36.2 a-c	34.6 ab	15.8 ab	3.3 a-d	7.2 ab	23.1 ab	3.9 ab	39 ab
CM1+NP3	35.9 a-c	34.0 abc	13.3 bcde	2.8 b-e	5.2 bc	21.8 ab	3.9 ab	33 b
CM2	32.5 d-f	28.7 cd	11.2 ef	3.2 a-d	5.2 bc	18.7 bc	3.3 ab	50 a
CM2+NP1	38.9 a	34.2 ab	14.5 abc	3.8 ab	7.2 ab	22.6 ab	4.1 a	36 b
CM2+NP2	35.5 a-d	35.5 ab	13.9 bcd	3.6 a-c	6.2 ab	21.3 ab	4.1 a	37 ab
CM2+NP3	34.1 c-e	30.3 bcd	11.8 def	3.3 a-d	6.0 abc	20.5 b	3.9 ab	37 b
2020	34.4	32.4	13.5	3.2	6.0	20.7	3.9	42
2021	34.8	32.7	13.1	3.3	6.3	21.5	3.7	33

Here, 40N+60P kg ha⁻¹ = (NP1), 40N+80P kg ha⁻¹ = (NP2), 40N+100P kg ha⁻¹ = (NP3), 2 t Chicken Manure ha⁻¹ = (CM1), 3 t Chicken Manure ha⁻¹ = (CM2), 2 t Chicken Manure ha⁻¹+40N+60P = (CM1+NP1), 2 t Chicken Manure ha⁻¹+40N+80P = (CM1+NP2), 2 t Chicken Manure ha⁻¹+40N+100P = (CM1+NP3), 3 t Chicken Manure ha⁻¹+40N+60P = (CM2+NP1), 3 t Chicken Manure ha⁻¹+40N+80P = (CM2+NP2) and 3 t Chicken Manure ha⁻¹+40N+100P = (CM2+NP3).

The differences among the means denoted by the same letters are not statistically significant at 5%.

Treatments of chemical fertilizer and chicken manure significantly increased the seed yield and number of pods plant⁻¹ by about 50% compared to the control (Figure 7).

Chicken manure and chemical fertilizer treatments were statistically significant seed yields in both years. Seed yield ranged from 1521.5 kg ha⁻¹ in control plots to 2742.1 kg ha⁻¹ in CM1+NP3 combination. The lowest yield was in only CM1 treatment after control. All NP fertilizer levels and chicken 3 t ha⁻¹ + all NP fertilizer level combinations produced seed yields with an increased rate of 40-50% compared to the control. Fertilizer treatments significantly increased the mean number of pods plant⁻¹ by 28% compared to the control, and the number of pods plant⁻¹ ranged from 12.7 to 19.3 (Figure 7). The highest number of pods per plant was observed in CM1+NP3 combination following to CM1+NP2 and CM2+NP3 combinations. The lowest number of pods per plant was in control, NP1 and CM1 treatments (Figure 7). It was observed that instead of using alone chicken manure and NP fertilizer treatments,

their combinations should be used at high or low rates in order to obtain a high grain yield and number of pods per plant. Similarly, Alhrouf *et al.* (2016) reported that the highest pod production was achieved by the combination of chicken manure with NPK fertilizer followed by chicken manure, NPK and control. Rurangwa *et al.* (2020) also noted that high yields could be achieved through the combined application of manure and NPK. Sachan and Krishna (2021) reported that the combination of organic and inorganic fertilizers is more effective than inorganic fertilizers or organic manure alone for the growth and yield of French beans.

Differences among fertilizer treatments for Spad and Green seeker values were significant, and spad values ranged from 29.6 in the control to 45.8 in CM2+NP3 combination. Spad and Green seeker observations were recorded at the flowering time only once (Figure 8). Fertilizer treatments caused changes in plant chlorophyll levels compared with control. Although the lowest Green seeker values were in control and CM1 treatment, there is no difference among other treatments.

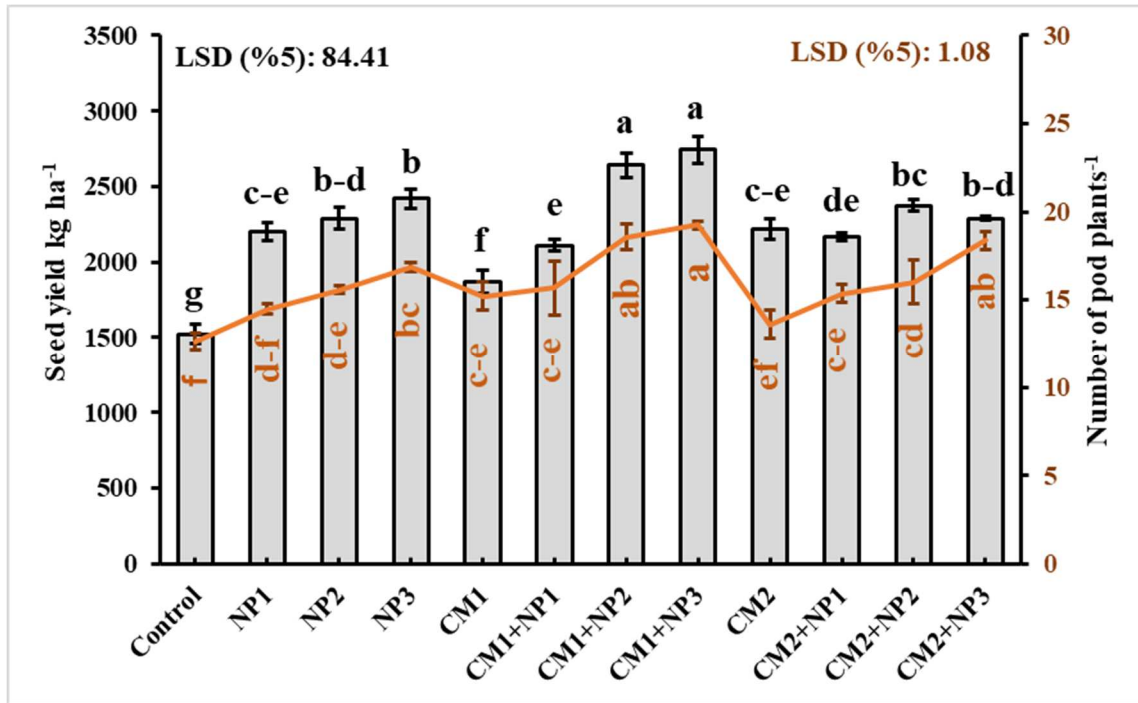
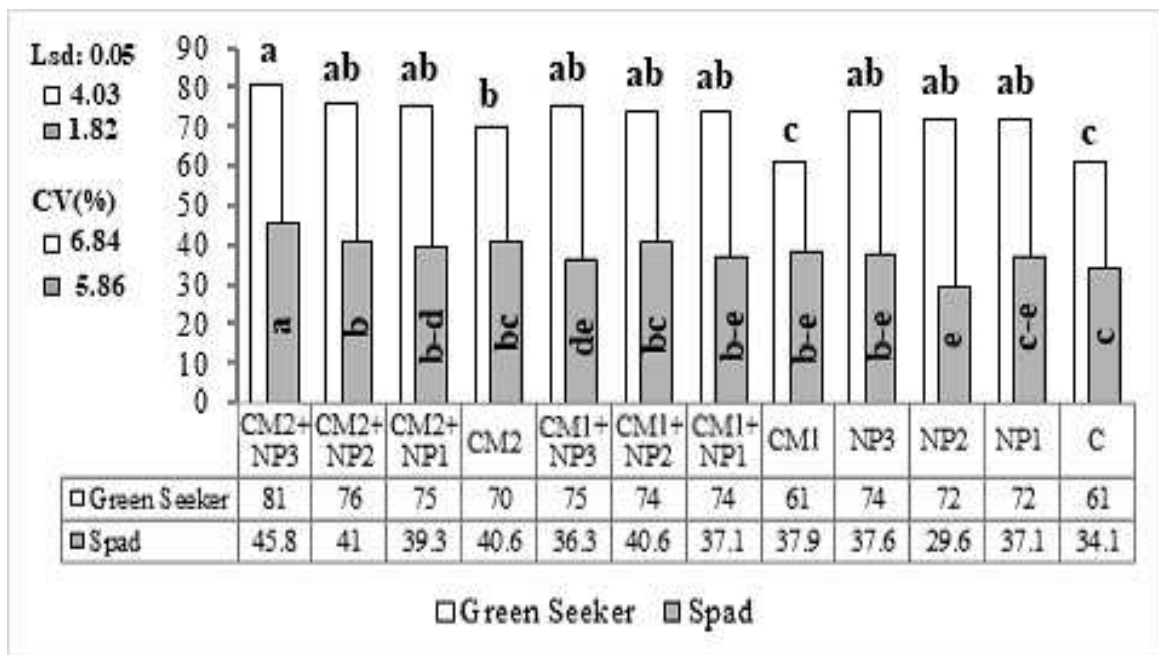


Figure 7. Seed yield (kg ha⁻¹) and number of pods per plant under chicken manure and chemical fertilizer
 Here, 40N+60P kg ha⁻¹ = (NP1), 40N+80P kg ha⁻¹ = (NP2), 40N+100P kg ha⁻¹ = (NP3), 2 t Chicken Manure ha⁻¹ = (CM1), 3 t Chicken Manure ha⁻¹ = (CM2), 2 t Chicken Manure ha⁻¹+40N+60P = (CM1+NP1), 2 t Chicken Manure ha⁻¹+40N+80P = (CM1+NP2), 2 t Chicken Manure ha⁻¹+40N+100P = (CM1+NP3), 3 t Chicken Manure ha⁻¹+40N+60P = (CM2+NP1), 3 t Chicken Manure ha⁻¹+40N+80P = (CM2+NP2) and 3 t Chicken Manure ha⁻¹+40N+100P = (CM2+NP3).



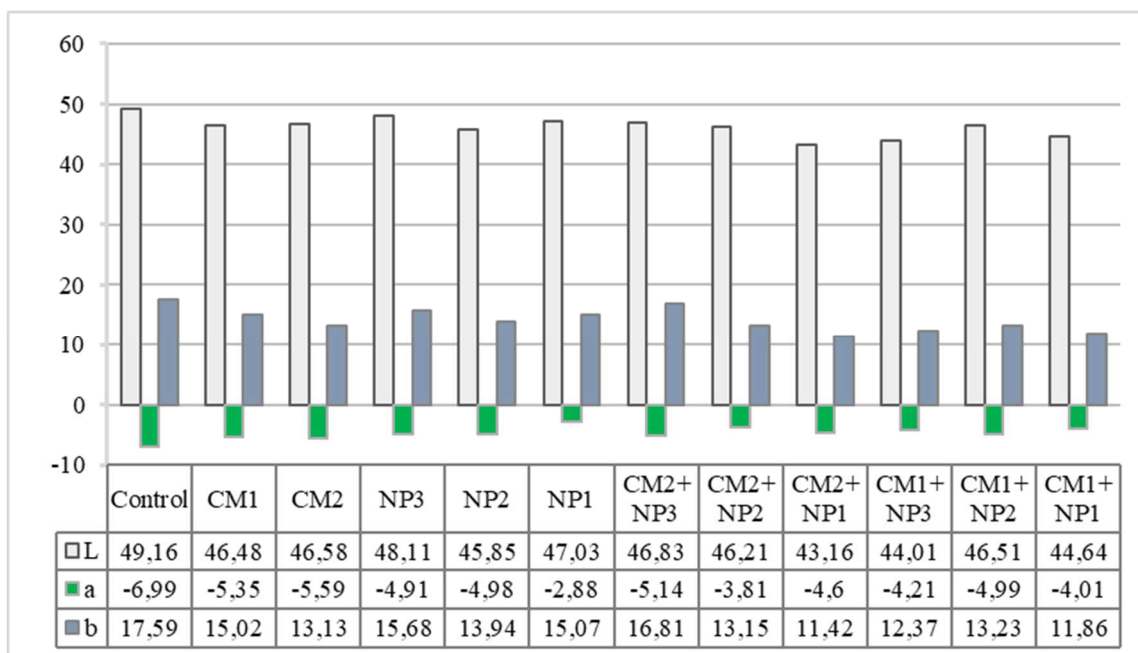


Figure 8. Green seeker, Spad and *Lab under chicken manure and chemical fertilizer

Here, 40N+60P kg ha⁻¹ = (NP1), 40N+80P kg ha⁻¹ = (NP2), 40N+100P kg ha⁻¹ = (NP3), 2 t Chicken Manure ha⁻¹ = (CM1), 3 t Chicken Manure ha⁻¹ = (CM2), 2 t Chicken Manure ha⁻¹+40N+60P = (CM1+NP1), 2 t Chicken Manure ha⁻¹+40N+80P = (CM1+NP2), 2 t Chicken Manure ha⁻¹+40N+100P = (CM1+NP3), 3 t Chicken Manure ha⁻¹+40N+60P = (CM2+NP1), 3 t Chicken Manure ha⁻¹+40N+80P = (CM2+NP2) and 3 t Chicken Manure ha⁻¹+40N+100P = (CM2+NP3).

Changes in the leaf color were observed at flowering time (Figure 8). Leaf color in terms of leaf greenness changed with treatments as a marker of the nitrogen nutrition status, which is assumed to be related to the leaf chlorophyll content. Leaf color, Spad and Green seeker values showed that plant health and development were positively affected by fertilizer treatments at flowering time. Similarly, Turner and Jund (1994) reported that leaf color was influenced by the plant growth stage, variety, leaf thickness, plant density, soil and climate factor.

Conclusions: In this study, it was revealed that the beans in the early stages of development did not uptake the existing chemical fertilizer although they were readily available in the soil. Since organic fertilizer dissolves more slowly, it was active during the period when the plant needed it and promoted more growth than chemical fertilizers. As the high doses of chicken manure (3 t ha⁻¹) and NP (100N+100P kg ha⁻¹) fertilizers combinations caused excessive use of the soil water, the plants were negatively affected in the final stage of plant development.

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