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YIELD RESPONSE OF COWPEA (*VIGNA UNGUICULATA* L.) TO POULTRY WASTE APPLICATION WITH DIFFERENT RATES OF POTASSIUM AND PHOSPHORUS INORGANIC FERTILIZERS

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Abstract

Poultry waste is a rich source of nitrogen nutrient compared to other elements. In crop cultivation, combined application of organic manures and inorganic fertilizers increase soil nutrients which are available to plants. Cowpea (*Vigna unguiculata* L. walp) is a significant grain legume production and it is used as a source of low cost protein for human consumption particularly in the developing countries. Thus, the experiment was conducted to determine the effects of poultry waste with phosphorus and potassium inorganic fertilizers on seed yield of cowpea (*Vigna unguiculata* L.). The pot experiment was designed in a Completely Randomized Design (CRD) with six treatments and seven replicates. Treatments included T1 – 100% inorganic fertilizer [35 kg ha^{-1} urea, 100 kg ha^{-1} triple superphosphate (100% TSP) and 75 kg ha^{-1} muriate of potash (100% MOP)], T2 – 10 t ha^{-1} poultry waste alone, T3 – 10 t ha^{-1} poultry waste + 25% TSP + 25% MOP, T4 – 10 t ha^{-1} poultry waste + 50% TSP + 50% MOP, T5 – 10 t ha^{-1} poultry waste + 75% TSP + 75% MOP, T6 – 10 t ha^{-1} poultry waste + 100% TSP + 100% MOP. The result confirmed that the poultry waste with potassium and phosphorus inorganic fertilizers had significant differences ($P<0.05$) on most of the agronomic parameters tested in this experiment. Results revealed that application of 10 t ha^{-1} poultry waste with 100% TSP and 100% MOP treatment (T6) showed the best treatment for cowpea yield in term of seed yield. But significant variation on seed yield was not observed between T5 (10 t ha^{-1} poultry waste with 75% TSP and 75% MOP treatment) and T6 (10 t ha^{-1} poultry waste + 100% TSP + 100% MOP) treatments. Therefore, application of 10 t ha^{-1} poultry waste reduces the usage of inorganic fertilizers (urea by 100%, TSP by 25% and MOP by 25%) for obtaining better seed yield in cowpea cultivation.

Keywords: Cowpea, inorganic fertilizer, poultry waste, seed yield

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Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a legume crop and it is a good source of protein which is a key part of the diet of people in most of the developing countries. It can be grown in rainfed settings provided that the minimum and maximum temperatures range from 28 to 30°C (day and night) during the cultivation period (Odundo, 2018). Cowpea can be cultivated as sole crop, intercrop, mixed crop and green manure crop for different purposes. With the increasing global population, food production needs to be increased therefore farmers use high amounts of inorganic fertilizers for obtaining high crop yield. However, excessive and continuous application of inorganic NPK fertilizers leads to environmental and soil health problem. Nitrogen is an important nutrient for crops as it helps in the creation of proteins, chlorophyll, and metabolic activities however upto 50% to 60% of nitrogen is lost through ammonia leakage, breakdown, and evaporation (Pradana *et al.*, 2021). The economic cost of inorganic fertilizers also has an influence on productivity (Jabbar and Ali Sbti, 2022). As a result, nowadays farmers are advised to use locally available organic manures effectively with reduced level of inorganic fertilizers to attain the optimum seed yield with less cost of production. Cattle manure, composts, poultry manure and green manures can be used in crop cultivation as replacement of the inorganic fertilizers.

Organic manure enhances soil fertility and improves crop production (Seran, 2016). It provides macro and micro nutrients to the crop and improves the physical, chemical, and biological soil prosperities (Purbajanti *et al*., 2019). The study on effectiveness of organic waste is necessary in order to improve soil productivity by using organic manure (Priyadharshini and Seran, 2009). Cowpea plants generally require nitrogen nutrients at the early vegetative stage of plant growth afterward it can fix atmospheric nitrogen in the soil under suitable conditions. Poultry waste contains relatively high content of nitrogen than phosphorus and potassium. Seran (2018) noted that farm yard manure alone or in combination with reduced level of recommended NPK fertilizers gave higher number of nodules compared to the recommended NPK fertilizers. Availability of phosphorus is a vital role in the nitrogen fixation process in the rhizobial symbiosis of legumes such as cowpea (Odundo, 2018). Potassium needs in various physiological processes in the growth and development of plant. Addition of poultry waste to the soil improves the level of mineral elements that of other animal manures due to its excellent nutritional value (Richa *et al*, 2020). In general, inorganic fertilizers release nutrients quickly while organic manures slowly discharge soil nutrients those are available to the plants. As a result, locally available organic manure with inorganic fertilizers at the required amount can be applied to improve the plant nutrients in soil. Cowpea is cultivated in Sri Lanka particularly in the rural areas where farmers are engaged in poultry farming. Hence, the present study was done to determine the effect of poultry waste with different rates of potassium and phosphorus inorganic fertilizers on yield of cowpea.

Methodology

This study was conducted in the experimental area at the Faculty of Agriculture, Eastern University, which is located in Eastern province of Sri Lanka. The experimental site is located at 7.7944° N, 81.5790° E and is a part of Sri Lankan dry zone low country (DL_1). This research study was carried out from July 2022 to November 2022. The annual mean temperature varies from 26 °C to 36 °C. Annual mean rainfall varies from 1400 mm to 1680 mm (Department of Meteorology, 2022). The precipitation amount ranges from 25 mm in the driest month (June) to 420 mm in the wettest one (December) in the experimental site where type of the soil is sandy regosol which contains low amounts of nitrogen (10.0 µg/g), phosphorus as P_2O_5 (40.0 µg/g), potassium as K_2O (0.25 meq/100 g) and organic carbon (0.3%) from the previous research work (Seran and Imthiyas, 2016). Cowpea cv waruni was used in this experiment. This variety erects and determinates growth habit and it is most popular cowpea variety used in the Eastern region of Sri Lanka. This experiment was laid out in a Completely Randomized Design (CRD) with six treatments having seven replications. Treatments used in this experiment were as follows:

T1 - 100% inorganic fertilizers (urea 35 kg ha^{-1}, 100 kg ha^{-1} TSP and 75 kg ha^{-1} MOP)

T2 - Poultry waste (10 t ha^{-1}) alone

T3 - Poultry waste (10 t ha^{-1}) + 25% TSP + 25% MOP

T4 - Poultry waste (10 t ha^{-1}) + 50% TSP + 50% MOP

T5 - Poultry waste (10 t ha^{-1}) + 75% TSP + 75% MOP

T6 - Poultry waste (10 t ha^{-1}) + 100% TSP + 100% MOP

For the pot experiment, black polybags (200 gauge thickness polythene) with a height of 30 cm and width of 30 cm were used and they were filled with sandy regosol soil. Each polybag was filled to the top of the polybag, leaving ¼ of space between the soil and the top of the polybag. Holes were made in the bottom of the polybags to remove the excess water. The polybags were kept in the experiment area at the spacing of 30 cm * 15 cm. In this experiment, basal fertilizers were applied but top dressing was not applied to determine the treatment effect on crop yield. According to the treatments, poultry waste (PW) containing 0.98 N: 0.57 P_2O_2: 0.16 K_2O (60 g per polybag equivalent 10 t ha^{-1}) was applied one week before planting while phosphorus and potassium inorganic fertilizers [100 kg ha^{-1} triple superphosphate (TSP) and 75 kg ha^{-1} muriate of potash (MOP)] were applied one day before planting. In this experiment, urea 35 kg ha^{-1} was added only to the control treatment (T1). Seeds of cowpea cv waruni were collected from Government Seed Center, Siyambalanduwa, Monaragala, Sri Lanka. Two seeds were planted in each polybag at a depth 2 cm then thinning out was practiced to maintain one plant per polybag. Watering was done every two days during the first three weeks and then every three days. Weeds were removed manually once in a week to maintain weed-free until harvesting.

Days to 50% flowers was recorded at the flowering stage and the total number of flowers per plant was counted at 5th week after planting. Harvesting was started at 8th week after planting in harvesting stage of cowpea. The number of mature pods in each plant was harvested and three pickings were performed. Leaf area per plant was measured after uprooting the plant by using leaf area meter (LI-3100, Germany). Fresh weights of the leaves, stem and root were measured by using analytical balance after uprooting the plants (after 8th week of planting). Dry weights of leaves, stem and root were also measured by using analytical balance after placing of leaves, stem and root in an oven drying at 105 ^{0}C for 6 hours. The collected cowpea pods were dried under sunlight for two days and then seeds were separated from the cowpea pods. Seed weight per plant was measured by using the analytical balance thereafter, seed yield was calculated. For statistical analysis, the collected data was analyzed using SAS statistical software (9.1 version). Analysis of variance was performed and treatment means were compared using Tukey's test at 5% significant level.

Results

Days to 50% flowering

Fig 1 shows effect of poultry waste with potassium and phosphorus inorganic fertilizers on number of days to 50% flowering in each treatment. A remarkable difference was not observed on the number of days taken for 50% flowering ($P>0.05$) however, the number of days taken for 50% flowering was slightly more in plants treated with 100% inorganic fertilizers (T1) or 10 t ha^{-1} Poultry waste alone (T2) than the other treatments. . The results also exhibited that flowering in cowpea plants was early when plants were treated with high levels of potassium and phosphorus inorganic fertilizers.

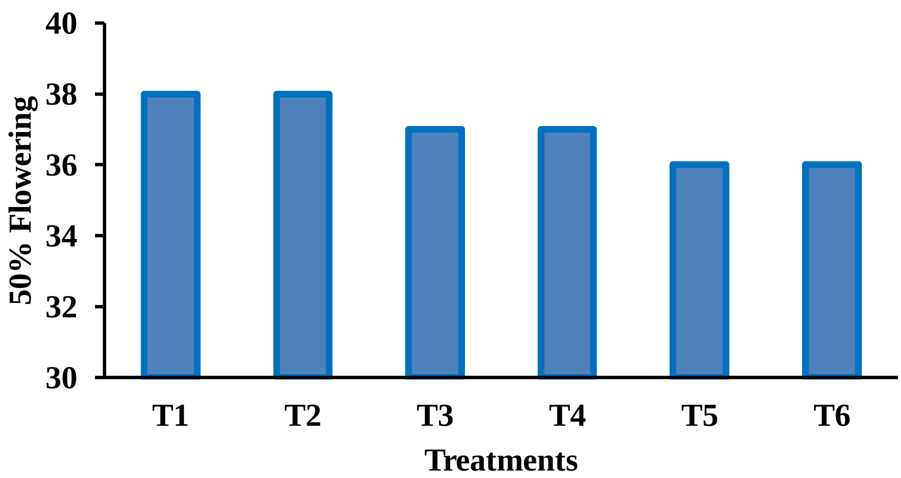

Figure 1: Effect of poultry waste with potassium and phosphorus inorganic fertilizers on number of days to 50% flowering in each treatment.

T1 - 100% inorganic fertilizers, T2 - 10 t ha^{-1} Poultry waste (PW) alone, T3 - 10 t ha^{-1} PW with 25% TSP + MOP, T4 - 10 t ha^{-1} PW with 50% TSP + MOP, T5 -10 t ha^{-1} PW with 75% TSP + MOP, T6 -10 t ha^{-1} PW with 100% TSP + MOP.

Number of flowers

The data presented in Table 1 clearly indicates that there was a significant variation (P<0.05) on number of flowers per plant by the application of poultry waste (PW) with potassium and phosphorus inorganic fertilizers. Use of PW (10 t ha^{-1}) with 100% TSP + MOP (T6) showed noticeable dissimilarity on number of flowers (P<0.05) compared with 100% inorganic fertilizers (T1). The maximum number of flowers was recorded in T6 treatment while minimum number of flowers was recorded in T1 as a control treatment.

Number of pods

Poultry waste with potassium and phosphorus inorganic fertilizers application significantly influenced (P<0.001) on number of pods per plant (Table 1). The remarkably lowest number of pods per plant was harvested in the control treatment (P<0.05) compared with other treatments. ,Highest number of pods per plant was achieved from plants grown in 10 t ha^{-1} PW with 100% TSP + MOP (T6) followed by 10 t ha^{-1} PW with 75% TSP + MOP (T5). . Further, it was noted that there was a substantial variation (P<0.05) on number of pods per plant between T5 and T6 treatments. On the other hand, insignificant differences were observed on the number of pods per plant (P>0.05) between T2, T3, T4 and T5.

Table 1: Effect of poultry waste with potassium and phosphorus inorganic fertilizers on number of flowers, number of pods and seed weight per plant.

Treatment	Number of flowers per plant	Number of pods per plant	Seed weight per plant (g)
T1	12.3b	09.1c	08.40c
T2	13.9ab	11.0b	10.05bc
T3	14.6ab	11.6b	10.83b
T4	14.3ab	11.4b	11.44b
T5	14.1ab	11.7b	12.31ab
T6	18.8a	14.4a	13.76a
F test	P<0.05	P<0.001	P<0.001

T1 - 100% inorganic fertilizers, T2 - 10 t ha^{-1} Poultry waste (PW) alone, T3 - 10 t ha^{-1} PW with 25% TSP + MOP, T4 - 10 t ha^{-1} PW with 50% TSP + MOP, T5 -10 t ha^{-1} PW with 75% TSP + MOP, T6 -10 t ha^{-1} PW with 100% TSP + MOP. Value represents mean of seven replicates. Means followed by the same letter in each column are not significantly different according to the Tukey's test at 5% significant level.

Leaf area

The data presented in Table 2 clearly indicates that there was a considerable consequence (P<0.001) on leaf area per cowpea plant after applying poultry waste with potassium and phosphorus inorganic fertilizers. Leaf area per plant was significantly high (P<0.05) in 10 t ha^{-1} PW with 100% TSP + MOP application (T6) than the other treatments except 10 t ha^{-1} PW with 75% TSP + MOP (T5). In spite of this, increase trend in leaf area was noted with increasing application (0 - 100%) of potassium and phosphorus inorganic fertilizers,

Table 2: Effect of poultry waste with potassium and phosphorus inorganic fertilizers on leaf area and as well as fresh and dry weights of leaves per plant.

Treatments	**Leaf area (cm^2)**	**Leaf fresh weight (g)**	**Leaf dry weight (g)**
T1	1279.42c	22.38b	4.71c
T2	1308.92c	25.10b	5.42bc
T3	1361.05bc	25.64ab	5.38bc
T4	1428.89bc	26.42ab	5.49abc
T5	1677.22ab	32.87a	6.85ab
T6	1729.65a	33.01a	7.01a
F test	P<0.001	P<0.001	P<0.001

T1 - 100% inorganic fertilizers, T2 - 10 t ha^{-1} Poultry waste (PW) alone, T3 - 10 t ha^{-1} PW with 25% TSP + MOP, T4 - 10 t ha^{-1} PW with 50% TSP + MOP, T5 -10 t ha^{-1} PW with 75% TSP + MOP, T6 -10 t ha^{-1} PW with 100% TSP + MOP. Value represents mean of seven replicates. Means followed by the same letter in each column are not significantly different according to the Tukey's test at 5% significant level.

Leaf weight

Application of poultry waste with phosphorus and potassium inorganic fertilizers had influence on the fresh weight of leaves per cowpea plant which is confirmed with P<0.001 values shown in Table 2. A significant differences were not observed (P>0.05) between applications of 100% inorganic fertilizers (T1), 10 t ha^{-1} Poultry waste (PW) alone (T2), 10 t ha^{-1} PW with 25% TSP + MOP (T3) and 10 t ha^{-1} PW with 50% TSP + MOP (T4). The low fresh weight of leaves was reported in plants grown in 100% inorganic fertilizers (T1) while the high weight was attained in 10 t ha^{-1} PW with 100% TSP + MOP (T6) followed by 10 t ha^{-1} PW with 75% TSP + MOP (T5). It was also noticed that there were no considerable differences (P>0.05) between T3, T4 T5 and T6. The data presented in Table 2 clearly indicates that there was remarkable effect (P<0.001) on dry weight of leaves per cowpea plant after applying poultry waste with potassium and phosphorus inorganic fertilizers. The high dry weight of leaves per plant was recorded in T6 followed by T5 and T4 but significant differences were not observed between T4, T5 and T6.

Stem weight

There was a significant difference ($P<0.001$) on fresh weight of stems as influenced by the application of poultry waste with phosphorus and potassium inorganic fertilizers (Table 3). Application of 100% inorganic fertilizers (T1) had low fresh weight of stem but relatively high weight was achieved in 10 t ha^{-1} PW with 100% TSP + MOP (T6) than other treatments. Table 3 also shows that there was substantial effect ($P<0.05$) among the treatments on dry weight of stem per cowpea plant after applying poultry waste with potassium and phosphorus inorganic fertilizers. The dry weight of stem per plant of the tested treatments ranged 10.26 g (T1) to 12.73 g (T6). Further it was noted that dry weight of stem in T6 treatment was differed remarkably ($P<0.05$) from that in the other treatments except 10 t ha^{-1} PW with 75% TSP + MOP treatment (T5).

Table 3: Effect of poultry waste with potassium and phosphorus fertilizers on fresh and dry weights of stem and root per plant as well as seed yield of cowpea.

Treatments	Stem fresh weight (g)	Stem dry weight (g)	Root fresh weight (g)	Root dry weights (g)	Seed yield g m^{-2}
T1	40.87b	10.60c	7.16bc	1.76ab	186.67c
T2	41.96b	10.98c	6.82c	1.68b	223.46bc
T3	46.09b	11.46bc	7.37bc	1.70ab	240.73b
T4	45.47b	11.26bc	8.04ab	1.75ab	254.37b
T5	44.36b	12.50ab	8.03ab	1.77ab	273.54ab
T6	53.02a	12.73a	8.58a	1.92a	305.81a
F test	$P<0.001$	$P<0.05$	$P<0.05$	$P<0.05$	$P<0.001$

T1 - 100% inorganic fertilizers, T2 - 10 t ha^{-1} Poultry waste (PW) alone, T3 - 10 t ha^{-1} PW with 25% TSP + MOP, T4 - 10 t ha^{-1} PW with 50% TSP + MOP, T5 -10 t ha^{-1} PW with 75% TSP + MOP, T6 -10 t ha^{-1} PW with 100% TSP + MOP. Value represents mean of seven replicates. Mean values in a column having the dissimilar letter/letters indicate significant differences according to Tukey's test at 5% significant level.

Root weight

In this experiment, the fresh and dry weights of roots per plant were significantly difference ($P<0.05$) between treatments by applying the poultry waste with potassium and phosphorus inorganic fertilizers (Table 3). According to the statistically analyzed data, minimum fresh and dry root weights were observed in 10 t ha^{-1} Poultry waste (PW) alone (T2). The plants which were treated with poultry waste (10 t ha^{-1}) with potassium

(100%) and phosphorus (100%) inorganic fertilizers (T6) had the higher root weight than the other treatments. Mean values in a column having the dissimilar letter indicate that insignificant variation was noticed between T1 (control treatment) and T6 treatments.

Seed weight per plant

Table 1 represents impact of poultry waste with potassium and phosphorus inorganic fertilizers on seed weight per cowpea plant. There was a significant variation ($P<0.001$) in seed weight per plant among the treatments. The high seed weight per plant was attained in use of 10 t ha^{-1} PW with 100% TSP + MOP (T6) followed by 10 t ha^{-1} PW with 75% TSP + MOP (T5) whereas low seed weight was recorded in 100% inorganic fertilizers (T1). The seed weight in T6 was considerably varied ($P<0.05$) compared with other treatments except T5. Based on the results obtained in the present experiment, it may be due to high leaf area and its weight in T5 and T6 (Table 2) it causes for increasing the photosynthetic activity and seed production.

Seed yield

Effect of poultry waste with phosphorus and potassium inorganic fertilizers on seed yield per square meter is shown in Table 3. There was a significant difference ($P<0.001$) in seed yield among the treatments. Maximum seed yield was obtained from plants grown in 10 t ha^{-1} PW with 100% TSP + MOP (T6) followed by 10 t ha^{-1} PW with 75% TSP + MOP treatment (T5). Minimum pod yield was recorded from plants in 100% inorganic fertilizers (T1). According to the results, there was no remarkable variation ($P>0.05$) between T5 and T6 on the other hand noteworthy effect on cowpea seed yield was noted ($P<0.05$) between T1 and T6 treatments.

Discussion

Early flowering in plants was noted when applied 10 t ha^{-1} PW with 75% TSP + MOP (T5) or 10 t ha^{-1} PW with 100% TSP + MOP (T6) compared with 100% inorganic fertilizers (T1) or 10 t ha^{-1} Poultry waste (PW) alone (T2). It might be due to the sufficient amount of potassium and phosphorus nutrients uptake from soil for its plant development in reproductive stage. Romheld and Kirkby (2010) also stated that potassium and phosphorus present in the organic manure increases the emergence of flowers in the plant. Early flowering is also a sign of forced crop maturity. Plant growth substances exciting in organic sources probably stimulate flower initiation consequently increase the number of flowers per plant (Palekar, 2006). Number of pods per plant was significantly ($P<0.05$) high in T6 than other treatments. Further, results indicated that there were no differences ($P>0.05$) between T2, T3, T4 and T5. This implies that high level (100%) of potassium and phosphorus inorganic fertilizers with poultry manure had a remarkable effect on number of pod formation. The finding is supported by Adebayo (2020) who stated that the ionic form of various nutrients, including nitrogen, phosphorus and potassium in soil is a crucial for crop growth and productivity. Ouda and Mahadeen

(2008) also reported that many species of living organisms are triggered by organic manures, releasing phytohormones that may stimulate plant growth and nutrient uptake. Khan *et al.* (2002) mentioned that phosphorus nutrient involves in regulating the pod formation because of enzymatic processes.

The poultry waste (PW) with potassium and phosphorus inorganic fertilizers had significant differences ($P<0.05$) on number of pods per plant, leaf area per plant, fresh and dry weights of leaves, stem and root, seed weight per plant and seed yield. Increasing tendency in leaf area, leaf weight and seed yield was also noted with increasing application of potassium and phosphorus inorganic fertilizers (0-100%) with poultry waste. The leaf area, leaf weight and stem weight were not considerably varied ($P>0.05$) between T1 and T2. On the contrary, these parameters in T5 and T6 were significantly differed from T1. The findings showed that application of 75-100% potassium and phosphorus inorganic fertilizers with poultry waste greatly influenced ($P<0.05$) on leaf and stem development than use of 100% inorganic fertilizers alone. Generally organic manure releases plant nutrients gradually which results in the availability of plant nutrients during their vegetative and reproductive growth period. In this experiment, the dry weight of leaves per plant of all the treatments ranged from 4.71 g (T1) to 7.01 g (T6). El-Sharawy *et al.* (2018) indicated that organic manure treatments had remarkable effect on the leaf area index of cowpea. Priyadarshani and Seran (2009) indicated that plants absorb less potassium which results in a decline in plant growth. In the present study, it was noticed that root dry weight of plants in 100% inorganic fertilizers (T1) was not considerably varied ($P<0.05$) from that in T2 and T6 while significant difference in root dry weight was observed ($P<0.05$) between 10 t ha^{-1} Poultry waste (PM) alone (T2) and 10 t ha^{-1} PW with 100% TSP + MOP (T6). This indicates that combined use of PW and inorganic fertilizers (phosphorus and potassium) improves root growth.

Viharnaa and Seran (2013) stated that organic manures increases availability of macro and micronutrients for enhancing the plant growth. An increase in photosynthetic activity directly increased the number and weight of seeds (Driever *et al.*, 2017). Increase in yield characteristics may be attributed to the high levels of organic nutrients in the manures that could enhance the vegetative growth of cowpea plants to accelerate the photosynthetic rate (Ahmed and Elzaawely, 2010). In the present study, seed yield of cowpea was high in plants grown in 10 t ha^{-1} PW with 100% TSP + MOP (T6) followed by 10 t ha^{-1} PW with 75% TSP + MOP (T5). Conversely, it was low in 100% inorganic fertilizers (T1). The findings were confirmed with result of Yoganathan *et al.* (2013) who mentioned that organic manure combined with inorganic fertilizer gave higher yield than the control treatment. Seran (2018) also confirmed that combined application of organic manure and inorganic fertilizer increased seed yield and quality than use of inorganic fertilizer alone.

Conclusion

The results revealed that the poultry waste (PW) with potassium and phosphorus inorganic fertilizers had a significant effect on seed yield of cowpea. High seed yield (305.81 g m^{-2}) was attained in plants grown in 10 t ha^{-1} PW with 100% TSP + MOP (T6) followed by T5 (273.54 g m^{-2}). Further, it was noted that seed yield in T6 was not significantly different from that in T5. Therefore, 10 t/ha poultry waste with 75% TSP and 75% MOP (T5) could be used for obtaining high seed yield of cowpea in sandy regosol than 100% inorganic fertilizers. As a result, Farmers can reduce usage of inorganic fertilizers in cowpea cultivation.

Conflict of interest

The authors declare no conflicts of interest.

Authors' contribution

GMSI performed the experiment. THS designed the study and analyzed the data. GMSI and THS contributed in writing the manuscript.

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