Designer seeds and fertilizer microdosing for increased cowpea productivity

ABSTRACT

An experiment was conducted at the Instructional Farm of the College of Agriculture, Kerala Agricultural University(KAU), Vellanikkara, Thrissur from October to December 2021, with the objective to assess the effect of fertilizer microdosing and designer seeds on the growth and yield of cowpea (*Vigna unguiculata* (L.)Walp).The treatments consisted of five levels of fertilizer microdosing (microdose 25%, 50%, 75% of NPK as per package of practices(POP) of KAU, NPK as per POP of KAU and absolute control) and three levels of seed treatments (designer seeds, rhizobium treated seeds, and untreated seeds). Result of the study indicated that, microdose and designer seeds significantly increased the biometric parameters and yield of cowpea. The combination microdose (50%) along with designer seeds resulted in the highest pod weight per plant and seed yield (43.80g and 969.87kg/ha, respectively).

Keywords: Designer seeds, fertilizer microdosing,biometric characters, seed yield

1. INTRODUCTION

Cowpea, *Vigna unguiculata*(L.) Walp, is oneof the most important grain legumes which iswidely cultivated in the semi-arid tropicsandsub-tropics,that contributes significantly to the nutritional security of the country. Cowpea yield remains low(less than 1 t ha^{-1})in most areas of India**(**Justin,et al.,2015)[5].It is highly essential to increase the productivity of cowpea. Application of fertilizersinmicrodosespermitmorepreciseandbettertimedfertilizerplacement and proper seed treatment techniques enhance vigour and viability. These techniques can be adopted to increase the productivity and nutrient use efficiency of cowpea.

Mineral fertilizers have been recognized as an entry point for a sustainableagricultureproductionsystem.However,overdosingonmineralfertilizershasseveralharmfuleffects.Applyingfertilizersinmicrodosespermitsmorepreciseandbettertimedfertilizerplacementandappropriatemanagementoffertilizers. According to Tsegay *et al*. (2019)[14], fertilizer microdosing lowers input costs while increasing production and efficiency of the usage of fertilizer. Fertilizer microdosing technology consistsoftheapplicationofasmallquantityofmineralfertilizer together with seeds of the target crop in theplanting hole at sowing or 3 to 4 weeks after planting(ICRISAT,2009)[4].

Seed fortification through designer seed technology increases seed production and quality which can be achieved by treating the seeds with nutrient solution, insecticides, bioagents and polymers.Designerseedisanintegratedpresowingseedtreatmentthatinvolvesthe additionofnutrients,plantprotectants,andbioinoculantstoenhanceseedquality, fieldemergenceandyieldattributingparameters(Sujatha andAmbika,2018)[12].

Thereisafeltneedtoincreasetheproductivityofcowpeawithlimitedresourcestoachievenutrientsecurityforthegrowingpopulation.Resourceconservation technologies such as designer seeds and fertilizer microdosing, to increase productivity andnutrient use efficiency are lacking. Hence, with this background, the present study was undertaken on cowpea with designer seed technology and fertilizer microdosing to maximize its productivity.

2. MATERIALS AND METHODS

The study was conducted at Instructional Farm, College of Agriculture, Kerala Agricultural

University (KAU), Vellanikkara, Thrissur (India) fromOctober to December, 2021. The experiment was laid out in Completely Randomized Design (Factorial), with 3 replications.Cowpea variety Anaswara was used for the study. The treatments consisted of five levels of fertilizer microdosing (microdose 25%, 50%, 75% of NPK as per POP of KAU, NPK as per POP of KAU and absolute control) and threelevels of seed treatments(Designer seeds, rhizobium treated seeds, and untreated seeds). Designer seeds were prepared by soaking seeds in a micronutrient solution (KAU sampoorna micronutrient mix) of 100ppm for 3 hours and drying back to original moisture content and then treating the seeds with polymer @ 3ml/kg of seed, imidacloprid @ 2ml/kg of seed, PGPR (plant growth promoting rhizobacteria) mix I @ 4g/kg of seed and rhizobium @ 20g/kg of seed.Rhizobium treated seeds were prepared by mixing rhizobium culture @ 20g/kg of seed along with rice gruel and shade dried for a few hours. For fertilizer microdosing, fertilizers were applied along with seeds at sowing, and top dressing was applied as hill placement. Conventional fertilization was done as basal placement.The growth parameters *viz.,*plant height, number of branches, days to 50 % flowering and dry matter production per plant were recorded at 20 days interval. Yield parameters *viz.*, pod weight per plant (g) and yield (kg/ha) were recorded at harvest. The data collected weresubjected to analysis using statistical package of KAU, 'GRAPES(General R based Analysis Platform Empowered by Statistics)'.

3. RESULTS AND DISCUSSION

The highest plant height, number of branches, and dry matter content per plant (54.90 cm, 7.00, and 28.15g) were recorded for microdose (50%) (Table 1). When compared to broadcasting, fertilizer microdosing increased the lateral root density in the topsoil by 72% and 40% at corresponding lateral distances of 25 cm and 50 cm (Okebalama, *et al*.,2017)[6]. Abdalla *et al*. (2015)[1]reported that, microdosing of phosphatic fertilizer improves plant height by 8 % and 3 % in sorghum and sesame respectively.

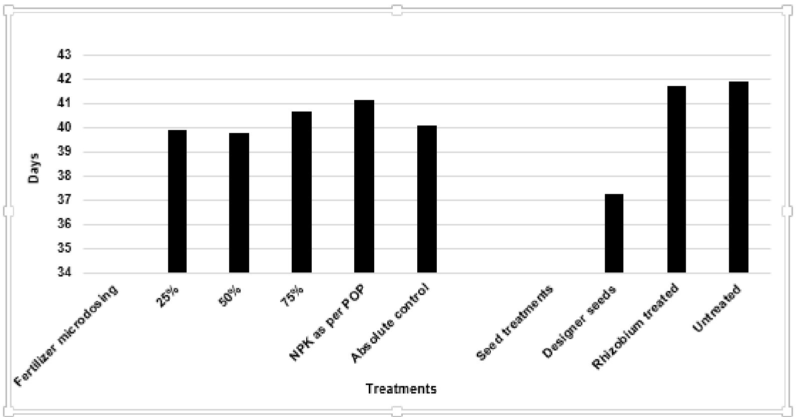
Among seed treatments, designer seeds showed the highest plant height, number of branches and dry matter content per plant (53.09cm, 6.13 and 23.90g respectively) (Table 1). Pelleting materials in designer seeds supply early micro and macronutrient supplements to plants during their early establishment. This could enhance the root and shoot growth in plants, which enabled the plants to absorb water and nutrients more effectively and grow more luxuriantly (Sujatha and Ambika, 2018)[11]. The KAU sampoorna micronutrient mix, consisting of essential elements such as Mg, S, B, Zn, Cu, Fe, Mn, and Mo was utilized as the micronutrient solution for the designer seed production. These elements are critical for various physiological functions in plants. Zinc, for instance, is an essential component of many enzymes, serving as a functional, structural, and regulatory cofactor. Copper acts as an enzyme activator and plays a crucial role in the absorption of nitrogen compounds, indirectly promoting chlorophyll production and increasing sugar content. Manganese and Zinc regulate protein metabolism and influence protein biosynthesis by adjusting the activity of peptidases. Iron promotes chlorophyll formation and enzyme mechanisms that work with cell respiratory systems, playing a role in cell growth and division. The synergistic effects of these elements were vital in the overall functioning and growth of cowpea (Saquee*et al*., 2023)[9].

Among fertilizer microdosing, microdose (50 %) showed minimum days(39.78 days) to 50% flowering which was on par with microdose (25 %) (39.89 days) (Fig.1). Through fertilizer microdosing tiny amounts of critical nutrients were added to deficient soil to help root systems to grow and absorb more water, which increases growth and development. Designer seeds showed a minimum of days to 50% flowering(37.27 days) as compared to other seed treatments(Fig. 1.). The polymer coating and nutrients of designer seeds could account for the beneficial effect observed in the field. This effect might be due to the activation of cells, which leads to a boost in mitochondrial activity. This process creates more high energy compounds and vital biomolecules that are available during the early stages of germination, thereby improving field emergence and early flowering (Seema *et al*.,2020)[10].

Table 1. Effect of treatments on plant height, number of branches and drymatter content per plant at harvest

Treatments	Plant height (cm)	Number of branches	Dry matter content per plant(g)
Fertilizer microdosing			
25% microdose	43.69	4.89	18.86
50% microdose	54.90	7.00	28.15
75% microdose	42.37	3.89	17.20
NPK as per POP	46.29	5.56	19.96
Absolute control	33.83	3.11	12.33
CD (0.05)	2.33	0.88	1.28
SE(m)±	0.81	0.31	0.44
Seed treatments			
Designer seeds	53.09	6.13	23.90
Rhizobium treated seeds	43.59	4.86	18.65
.27Untreated seeds	35.97	3.67	15.27
CD (0.05)	1.81	0.68	0.99
SE(m)±	0.63	0.24	0.34

Fig. 1. Effect of treatments on days to 50% flowering



The highest pod weight per plant (35.16 g) and seed yield (640.24 kg/ha) were found in microdose (50 %)(Table 2). Observational data suggests that crop yield enhanced when microdosing techniques are employed. A reduction of fertilizer application by 50% resulted in a 19% increase in seed yield. The practice of microdosing fertilizer enables plants to receive precise amounts of nutrients, minimizing wastage and optimizing uptake. This targeted approach ensures balanced growth, avoiding nutrient imbalances that are caused from excess or deficiency. As a result, nutrient efficiency is enhanced, leading to healthier plants and overall improved yield and productivity. According to Ibrahim,*et al*. (2015)[3], lateral root growth within the topsoil allows for better nutrient utilization, which in turn leads to a good effect of fertilizer microdosing in improving millet yield. Among seed treatments, designer seeds showed the highest pod weight per plant (36.56g) and seed yield (683.43 kg/ha).Designer seed treatment resulted in 38% and 114 %increase in yield as compared to rhizobium treated seeds and untreated seeds respectively. The inclusion of inoculants, protectants, nutrients, and polymer in the coating treatment may have contributed to the yield increase. Bioinoculantsused for seed treatment were also contributed in plant growth by the solubilization and sequestration of various plant nutrients, and their subsequent delivery to the plants (Dinesh *et al*., 2018)[2].

Table 2. Effect of treatments on pod weight per plant, number of grains per pod and seed yield at harvest

Treatments	Pod weight per plant (g)	Seed yield (kg/ha)
Fertilizer microdosing		
25% microdose	33.59	579.16
50% microdose	35.16	640.24
75% microdose	28.53	482.73
NPK as per POP	31.01	536.49
Absolute control	21.53	258.25
CD (0.05)	1.41	15.28
SE(m)±	0.49	5.29
Seed treatments		
Designer seeds	36.56	683.43
Rhizobium treated seeds	28.75	494.88
Untreated seeds	24.59	319.82
CD (0.05)	1.09	11.83
SE(m)±	0.38	4.09

The results of the experiment showed that the treatment combination of microdose (50 %) with designer seeds (T4) yielded the most significant positive effects on plant height (66.70 cm), number of branches (8.00), and dry matter content per plant (36.11g) (Table 3). On the other hand, the lowest values were observed in absolute control with untreated seeds, with plant height, number of branches, and dry matter content per plant measuring 30.40cm, 2.33, and 10.53g, respectively (Table 3).Treatment combinations T1 (microdose (25%) + designer seed), T4 (microdose (50 %) + designer seeds) and T13 (absolute control + designer seed) were recorded minimum days (35.67 days) for 50% flowering compared to absolute control with untreated seeds (42.33 days) (Fig. 2). According to Rakotoson *et al*., (2021)[8], vigorous growth, early flowering and accumulation of nutrients was observed in rice seedlings under fertilizer microdosing. Designer seeds of black gram showed increased plant growth, vigour and took minimum days for 50 per cent flowering as compared to untreated control (Sujatha and Ambika, 2016)[12].Thus, it was found that the microdose (50 %) and designer seed combination performed better in terms of biometrics and early flowering.

Table 3. Interaction effect of treatments on plant height, number of branches and dry matter content per plant of cowpea at harvest

Treatments		Plant height (cm)	Number of branches	Dry matter content per plant (g)
T1	25% microdose + designer seed	52.43	6.33	25.48
T11	NPK as per POP + rhizobium treated	47.03	5.33	16.70
T12	NPK as per POP+ untreated seed	36.30	4.67	13.50
T13	Absolute control + designer seed	38.83	3.67	13.57
T14	Absolute control + rhizobium treated	32.27	3.33	12.63
T15	Absolute control + untreated seed	30.40	2.33	10.53
	CD (0.05)	4.04	1.31	2.21
	SE(m)±	1.40	0.41	0.76

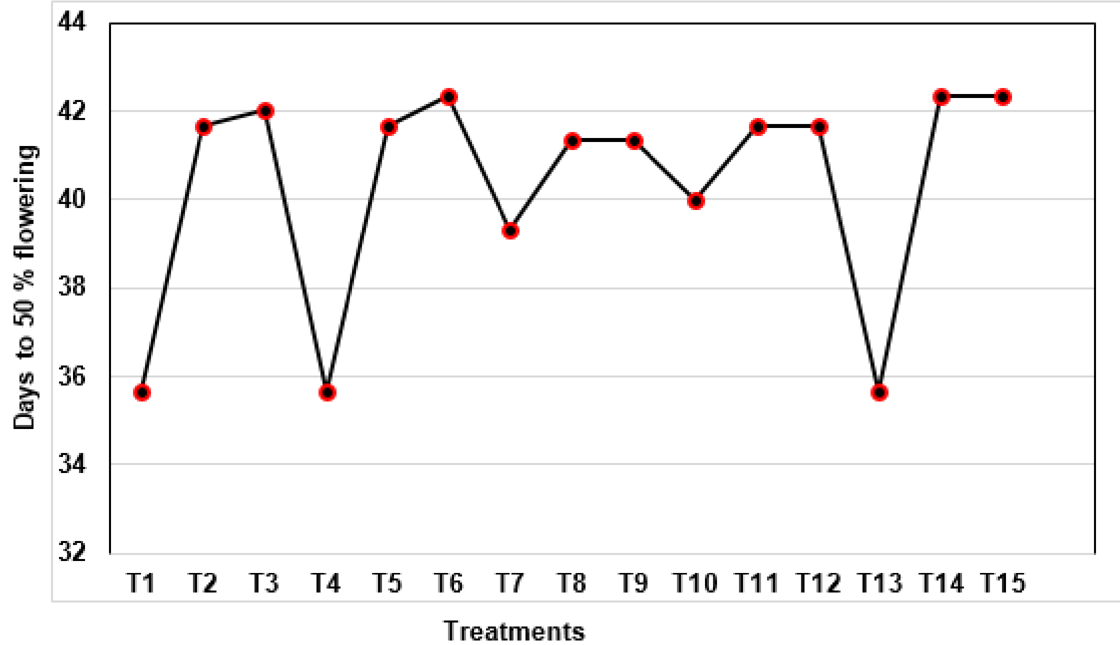


Fig. 2. Interaction effect of treatments on days to 50% flowering

The highest yield attributes *viz*., pod weight per plant (44.55g)and seed yield (969.87kg) were found in the treatment combination, 50% microdose with designer seed treatment (T4) (Table 4). The seed yield recorded by NPK as per POP with designer seeds (T10) was 736.60 kg/ha. There was a 32 % improvement in yield when fertilizer application was reduced by 50%. Fertilizer microdosing led to a significant rise in the leaf area index and leaf chlorophyll content in millets (Ibrahim, *et al*.,2015)[3]. These could improve photosynthesis and lead to increased production when fertilizer is microdosed. Tovihoudji*et al*. (2017)[13] also reported increased productivity by 50 % in maize under fertilizer microdosing.

The surge in yield in designer seeds may be attributed to the improved photosynthetic efficiency, which stabilizes chlorophyll and increases the production of photosynthates. Consequently, organic material is transported more efficiently from the source to the sink in the treated plants.The application of coating treatment containing inoculants, protectants, nutrients, and polymers also appears to have contributed to the observed yield increase. Plant development and yield were enhanced by biologically active productsand these products facilitate biological nitrogen fixation, phosphate mobilization, and nutrient uptake (Ponnuswamy*and Vijayalakshmi.,* 2011)[7].Similar findings are also reported in paddy, and black gram where, polymer coating accelerated the uptake of water, gasses, minerals, and hormones that promote early panicle emergence, faster development, and swift seedling emergence (Sujatha and Ambika, 2018)[11].

Table 4. Effect of treatments on pod weight and seed yield of cowpea at harvest

Treatments		Pod weight per plant (g)	Seed yield (kg/ha)
T1	25% microdose + designer seed	41.06	842.67
T2	25% microdose + rhizobium treated	29.62	559.10
T3	25% microdose + untreated seed	25.63	313.77
T4	50% microdose + designer seed	44.55	969.87
T5	50% microdose + rhizobium treated	34.23	596.26
T6	50% microdose + untreated seed	26.70	364.10
T7	75% microdose + designer seed	34.15	562.17
T8	75% microdose + rhizobium treated	26.92	513.70
T9	75% microdose + untreated seed	24.53	372.33
T10	NPK as per POP+ designer seed	37.78	736.60
T11	NPK as per POP + rhizobium treated	31.59	559.10
T12	NPK as per POP+ designer seed	28.14	335.70
T13	Absolute control + designer seed	25.27	315.33
T14	Absolute control + rhizobium treated	21.37	246.23
T15	Absolute control + untreated seed	17.97	213.20
	CD (0.05)	2.45	26.47
	SE(m)±	0.85	9.16

4. CONCLUSION

Results of the study indicated that, fertilizer microdose (50%) and designer seeds helped to increase 148 % and 114 % yield as compared to absolute control and untreated seeds respectively. The combination of microdose (50 %) with designer seeds proved to be the most effective treatment in terms of biometric and yield attributes. Incorporating resource-efficient technologies, such as fertilizer microdosing and designer seeds, can significantly enhance the growth and yield of cowpea.

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