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Significance of foliar nutrition on growth indices, yield attributes and yield of cowpea (*Vigna unguiculata*)

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Abstract
A field experiment was conducted at Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vigyan Kendra (GKVK), University of Agricultural Sciences (UAS), Bangalore, to evaluate the impact of foliar nutrition on growth and yield of cowpea under changing climate. The experiment consists of different types and combinations of foliar spray (DAP, Pulse magic and Ampoxcilin) totally there are thirteen treatments replicated thrice in RCBD. Combined application of 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxicilin recorded significantly higher leaf area plant^{-1} (1137 cm^2), leaf area index (2.53), absolute growth rate (0.358 g plant^{-1} day^{-1}), relative growth rate (0.043 g g^{-1} day^{-1}), crop growth rate (7.96 g m^{-2} day^{-1}) and net assimilation rate (5.791 g dm^{-2} day^{-1}) of cowpea. The yield attributes and yield were significantly varied with 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin. Higher number of pod plant^{-1} (27.8), Pod length (18.1 cm) number of seeds pod^{-1} (17.5), seed yield (1357 kg ha^{-1}) and haulm yield (3550 kg ha^{-1}) were recorded. Whereas, lower number of pods plant^{-1} (20.6), pod length (14.7 cm), number of seeds pod^{-1} (13.5), seed yield (859 kg ha^{-1}) and haulm yield (2153 kg ha^{-1}) of cowpea were recorded with 75% RDF + Water spray.

Keywords: Cowpea, DAP, Pulse magic, Ampoxcilin, growth indices and yield

Introduction
Cowpea [*Vigna unguiculata* (L.) Walp.] commonly known as *lobia* is one of the important *kharif* pulse crop grown for grain, forage and green manuring. The crop has heavy vegetative growth which covers the ground fully and checks the soil erosion in problem areas It can be later ploughed down for green manuring. It has considerable promise as an alternative pulse crop in dry land farming. It is also called as vegetable meat due to high amount of protein in grain and better biological value on dry weight basis. Besides being a rich source of protein; they maintain soil fertility through biological nitrogen fixation in soil and thus play a vital role in furthering sustainable (Salih, 2013) [10]. The present cowpea nutrition status was limited to the basal application of fertilizers for nitrogen and phosphorus. To enhance productivity of cowpea intermittent supply of nutrients during crop growth period is crucial. The nutrients when added in small amount by exogenous foliar application, modify the natural growth regulatory system right from seed germination to senescence in several pulses. Among several strategies to boost the productivity and quality of cowpea, foliar application of nutrients will be a vital. The foliar applied nutrients are more effective as compared to soil applied nutrients. Because of higher uptake efficiency, foliar supply of nutrients can increase photosynthetic efficiency by delaying the leaf senescence. An effort, therefore, was made in this study to find out the significance of foliar nutrition on growth indices, yield attributes and yield of cowpea.

Material and Methods
The experiment was conducted at Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vigyan Kendra (GKVK), University of Agricultural Sciences (UAS), Bangalore. The center is situated in the agro-climatic zone V: (Eastern Dry Zone) of Karnataka at 12°58' North latitude and 77°35' East longitude with an altitude of 930 m above mean sea level. The soil of the experimental site was red sandy loam in texture, classified under the order *Alfisols*. The composite soil samples from 0 to 30 cm depth were collected randomly in experimental area before sowing from each replication. The moisture content at field capacity was 18.63 per cent with a bulk density of 1.43 g cc^{-1}. The soil of the site was slightly acidic in reaction (pH 6.05) with medium electrical conductivity (0.30 dS m^{-1}) and organic carbon content (0.43%). It had low available nitrogen (242.04 kg ha^{-1}), medium phosphorus (26.13 kg ha^{-1}) and medium potassium (281.31 kg ha^{-1}), respectively (Table 1).

The experiment included of thirteen treatments laid out in randomized complete block design with three replications. Treatments includes application of nutrients through foliar spray. T_1 =100% RDF (Control), T_2 =100% RDF +2% DAP at 40 DAS,T_3=100% RDF+2% Pulse magic at 40 DAS, T_4 = 100% RDF+0.2% Ampoxcilin at 40 DAS, T_5 = 75% RDF+2% DAP at 40 DAS, T_6=75% RDF+2% Pulse magic at 40 DAS, T_7 = 75% RDF + 0.2% Ampoxicilin at 40 DAS, T_8 = 75% RDF +2% DAP + 2% Pulse magic at 40 DAS, T_9 = 75% RDF +2% DAP + 0.2% Ampoxicilin at 40 DAS, T_{10} = 75% RDF+2% Pulse magic + 0.2% Ampoxicilin at 40 DAS, T_{11} = 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxicilin at 40 DAS,T_{12} = 100% RDF + Water spray and T_{13} = 75% RDF + Water spray. The cowpea variety KBC -2 seeds were sown in lines at the rate of 25 kg ha^{-1} at a depth of 2-3 cm, maintaining 45 cm row to row and 10 cm plant to plant spacing. The crop was fertilized with 25 kg N, 50 kg P_2O_5 and 25 kg K_2O through urea, single super phosphate and muriate of potash, respectively. The different growth indices were calculated using the following formula.

Table 1: Physical and chemical properties of soil at the experimental site

Particulars	Values	Status	Method followed
I. Physical properties			
1. Coarse sand (%)	53.4	Red sandy loam soil	International pipette method (Piper, 1966) [9]
2. Fine sand (%)	14.8		
3. Silt (%)	16.6		
4. Clay (%)	15.2		
II. Chemical properties			
1. pH (1:2.5)	6.05	Acidic	Potentiometric method Jackson (1973) [6]
2. EC (1:2.5) (dSm^{-1})	0.30	Normal	Conductometric method (Jackson, 1973) [6]
3. Organic carbon (%)	0.43	Low	Wet oxidation method (Walkley and Black, 1934) [15]
4. Available N (kg ha^{-1})	242.0	Low	Alkaline potassium permanganate method (Subbiah and Asija, 1956) [13]
5. Available P_2O_5 (kg ha^{-1})	26.1	Medium	Bray's method (Jackson, I973) [6]
6. Available K_2O (kg ha^{-1})	281.3	Medium	Flame photometry (Jackson, 1973) [6]

Leaf area index

$$LAI = \frac{\text{Leaf area plant}^{-1}\ (cm^2)}{\text{Spacing } (cm^2)} \times 100$$

Absolute growth rate (AGR)

Absolute growth rate refers to the total dry matter accumulation per plant and per unit time. For various growth periods it was worked out from the below mentioned formula of Watson (1952) [16] and expressed in g plant^{-1}day^{-1}.

$AGR = W_2-W_1/t_2-t_1$

Where,

W_2 = Dry matter production plant^{-1} (g) at t_2

W_1 = Dry matter production plant^{-1} (g) at t_1

T_1 and t_2 = Time intervals

Crop growth rate (CGR)

Crop growth rate for various growth periods was worked out from the below given formula of Watson (1952) [16] and expressed in g m^{-2} day^{-1}.

$CGR = W_2-W_1 / t_2-t_1 x\ P$

Where,

W_2 = Dry matter production plant^{-1} (g) at t_2

W_1 = Dry matter production plant^{-1} (g) at t_1

T_1 and t_2 = Time intervals

P = Land area (m^2)

Relative growth rate (RGR)

Relative growth rate for various growth periods was worked out from the below given formula of Watson (1952) [16] and expressed in g g^{-1} day^{-1}.

$RGR = 1/w \times dw/dt = (\log_e w_2 - \log_e w_1) / (t_2 - t_1)$

Where,

W = Dry weight of plant

DW = Change in weight

DT = Time interval

W_2 and w_1 = Dry weight of plant at time T2 and T1

Net assimilation rate (NAR)

Net assimilation rate is defined as the rate of increase of dry weight per unit of leaf area. NAR for various growth periods was worked out from the below given formula of Gregory (1926) and expressed in g dm^{-2} day^{-1}.

$NAR = W_2-W_1/t_2-t_1 x\ LogeL_2-LogeL_1/L_2-L_1$

Where,

W_2 = Dry matter production per plant (g) at t_2

W_1 = Dry matter production per plant (g) at t_1

T_1 and T_2 = Time intervals.

L1 = Leaf area index (LAI) at time t1

L2 = LAI at time t2

Results and Discussion

Effect on growth indices

The data pertaining to leaf area plant^{-1} and leaf area index of cowpea as influenced by different foliar nutrition presented in table 2. Leaf area plant^{-1} was lowest during early stages and gradually increased with increase in age of the crop and reached its peak at 60 DAS and thereafter shown declining trend towards maturity due to senescence of leaves. At 30 DAS there was no significant difference among all the treatments with respect to leaf area plant^{-1} and leaf area index. The significant difference was observed in leaf area plant^{-1} of cowpea due to different foliar nutrition at 60 DAS. The maximum leaf area plant^{-1} of 1250 cm^2 was recorded with the application of 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin foliar spray. But, it was on par with 75% RDF + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS and 75% RDF + 2% DAP + 2% Pulse magic at 40 DAS (1223 and 1183 cm^2 plant^{-1}, respectively). Minimum leaf area plant^{-1} (832 cm^2) was recorded in 75% RDF + Water spray. At the time of harvest, significantly higher leaf area plant^{-1}(1137 cm^2) of cowpea was observed with the application of 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS followed by application of 75% RDF + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS and 75% RDF + 2% DAP + 2% Pulse magic at 40 DAS (1118 cm^2 plant^{-1} and 1080 cm^2 plant^{-1}, respectively). However, lower leaf area plant^{-1} (782 cm^2) was observed with 75% RDF + Water spray (Table 2). The leaf area plant^{-1} of cowpea increased linearly at different crop growth stages and reached maximum at 60 DAS and there after starts declining due to leaf senescence up to the

time of harvest. The highest leaf area plant^{-1} was recorded with application of 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS might be due to the balanced supply of nutrients to plant which promoted the plant growth process. The increments in the growth traits through micronutrient foliar application due to its role in the synthesis of metabolic products and activation of many enzymes which in turn affect the plant growth. These results are also in line with earlier findings of Dixit and Elamathi (2007) [3], Shashikumar *et al.* (2013) [11], Deotale *et al.* (2015) [2] and Thakur *et al.* (2017) [14].

Table 2: Leaf area plant^{-1} and leaf area index at different growth stages of cowpea influenced by foliar nutrition

Treatments	Leaf area (cm^2 plant^{-1})			Leaf area index		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1	432	840	797	0.96	1.87	1.77
T_2	404	1043	947	0.90	2.32	2.10
T_3	415	1060	960	0.92	2.36	2.13
T_4	471	1013	910	1.05	2.25	2.02
T_5	408	1023	937	0.91	2.27	2.08
T_6	440	1083	997	0.98	2.41	2.21
T_7	414	960	910	0.92	2.13	2.02
T_8	306	1183	1080	0.68	2.63	2.40
T_9	427	1107	1013	0.95	2.46	2.25
T_{10}	425	1223	1118	0.94	2.72	2.48
T_{11}	431	1250	1137	0.96	2.78	2.53
T_{12}	435	853	800	0.97	1.90	1.78
T_{13}	426	832	782	0.95	1.85	1.74
S. Em. ±	45	35	37	0.10	0.08	0.08
C.D. (P=0.05)	NS	101	108	NS	0.23	0.24

T_1: 100% RDF (Control)
T_2: 100% RDF + 2% DAP at 40 DAS
T_3: 100% RDF + 2% Pulse magic at 40 DAS
T_4: 100% RDF + 0.2% Ampoxcilin at 40 DAS
T_5: 75% RDF + 2% DAP at 40 DAS
T_6: 75% RDF + 2% Pulse magic at 40 DAS
T_7: 75% RDF + 0.2% Ampoxcilin at 40 DAS
T_8: 75% RDF + 2% DAP + 2% Pulse magic at 40 DAS
T_9: 75% RDF + 2% DAP + 0.2% Ampoxcilin at 40 DAS
T_{10}: 75% RDF + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS
T_{11}: 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS
T_{12}: 100% RDF + Water spray
T_{13}: 75% RDF + Water spray

At 60 DAS, among the different treatments foliar application with 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin recorded significantly higher leaf area index (2.78), which was statistically on par with the 75% RDF + 2% Pulse magic + 0.2% Ampoxcilin (2.72) and 75% RDF + 2% DAP + 2% Pulse magic (2.63). Lower leaf area index (1.85) was recorded with 75% RDF + Water spray. At the time of harvest, application of 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS recorded significantly higher leaf area index (2.53) followed by application of 75% RDF + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS and 75% RDF + 2% DAP + 2% Pulse magic at 40 DAS (2.48 and 2.40, respectively). However, lower leaf area plant^{-1} (1.74) was observed with 75% RDF + Water spray. The LAI is also related to the supply and availability of nitrogen to plants which is supplied by the source of DAP and pulse magic, which helps in maintaining the opening of stomata for longer period both in optimum and adverse conditions during the crop growth period which led to increased LAI providing stronger source for sink. Higher LAI might be due to the positive influence of foliar spray of nutrients on cell division and cell elongation which facilitates better crop growth and development. Above results are in line with that of Mahmoud *et al*. (2006) [8] and Cheghakhor *et al*. (2009) [1].

The data pertaining to absolute growth rate (AGR), relative growth rate (RGR), crop growth rate (CGR) and net assimilation rate (NAR) as influenced by different combinations of foliar nutrition are presented in Table 3. At 30 to 60 DAS, AGR, RGR, CGR and NAR of cowpea affected significantly due to different combinations of foliar nutrition. Significantly higher AGR (0.358 g plant^{-1} day^{-1}), RGR (0.043 g g^{-1} day^{-1}), CGR (7.96 g m^{-2} day^{-1}) and NAR (5.791 g dm^{-2} day^{-1}) were recorded with the application of 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS and lower AGR, RGR, CGR and NAR (0.187 g plant^{-1} day^{-1}, 0.026 g g^{-1} day^{-1}, 4.17 g m^{-2} day^{-1} and 5.791 g dm^{-2} day^{-1}, respectively) was observed with 75% RDF + Water spray. Higher growth indices like AGR, RGR CGR and NAR were recorded in 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin treatment due to the fact that those plants were get balanced supply of nutrients at the critical stages which enables them to have higher leaf area, leaf area index and photosynthetic rate and leaf angle is an index of amount of light interception. Thus, enhancing the crop growth. These findings are in conformity with the results obtained by Sritharan *et al.* (2015) [12] and Gagandeep *et al.* (2015) [4].

Table 3: Influence of foliar nutrition on growth indices (AGR, CGR, RGR and NAR) at 30-60 DAS of cowpea

Treatments	AGR (g day-1)	RGR (g g^{-1} day^{-1})	CGR (g m^{-2} day^{-1})	NAR (g dm^{-2} day^{-1})
T_1	0.193	0.028	4.29	3.938
T_2	0.254	0.033	5.64	4.188
T_3	0.263	0.033	5.84	4.088
T_4	0.222	0.032	5.27	4.017
T_5	0.250	0.032	5.56	4.496
T_6	0.262	0.036	5.83	4.126
T_7	0.242	0.034	5.24	4.471
T_8	0.333	0.039	7.39	4.466
T_9	0.292	0.037	6.48	4.939
T_{10}	0.336	0.040	7.47	5.057
T_{11}	0.358	0.043	7.96	5.791
T_{12}	0.194	0.027	4.31	4.511
T_{13}	0.187	0.026	4.17	3.549
S. Em. ±	0.017	0.002	0.28	0.249
C.D. (P=0.05)	0.050	0.005	0.81	0.728

T_1: 100% RDF (Control)
T_2: 100% RDF + 2% DAP at 40 DAS
T_3: 100% RDF + 2% Pulse magic at 40 DAS
T_4: 100% RDF + 0.2% Ampoxcilin at 40 DAS
T_5: 75% RDF + 2% DAP at 40 DAS
T_6: 75% RDF + 2% Pulse magic at 40 DAS
T_7: 75% RDF + 0.2% Ampoxcilin at 40 DAS
T_8: 75% RDF + 2% DAP + 2% Pulse magic at 40 DAS
T_9: 75% RDF + 2% DAP + 0.2% Ampoxcilin at 40 DAS
T_{10} : 75% RDF + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS
T_{11}: 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS
T_{12}: 100% RDF + Water spray
T_{13}: 75% RDF + Water spray

Effect on yield attributes and yield

The data on yield attributes and yield of cowpea namely number of pods plant^{-1}, pod length, number of seeds pod^{-1}, test weight (g), seed yield (kg ha^{-1}) and haulm yield (kg ha^{-1}) as influenced by different foliar nutrition are presented in Tables 4 and Figure 1. At the time of harvest, significantly higher number of pods plant^{-1} (27.8), pod length (18.1 cm), number of seeds pod^{-1} (17.5), higher test weight (10.4 g), seed yield (1357 kg ha^{-1}) and haulm yield (3550 kg ha^{-1}) of cowpea were recorded with application of 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxcilin at 40 DAS. Lower number of pods plant^{-1} (20.6), pod length (14.7 cm), seeds pod^{-1} (13.5), test weight (9.5 g), seed yield (859 kg ha^{-1}) and haulm yield (2153 kg ha^{-1}) were observed with 75% RDF + Water spray. Foliar spray during critical stages of crop growth enhanced photosynthetic activity and higher uptake of nutrients and there by increased plant dry matter production in the pod setting phase which might have improved the pod development and number of pods plant^{-1} and finally contributed for higher productivity. Adequate supply of N, P and K through foliar application would have increased its uptake and dry matter. These results are in confirmation with the results of Jayarani Reddy *et al.* (2004) [7].

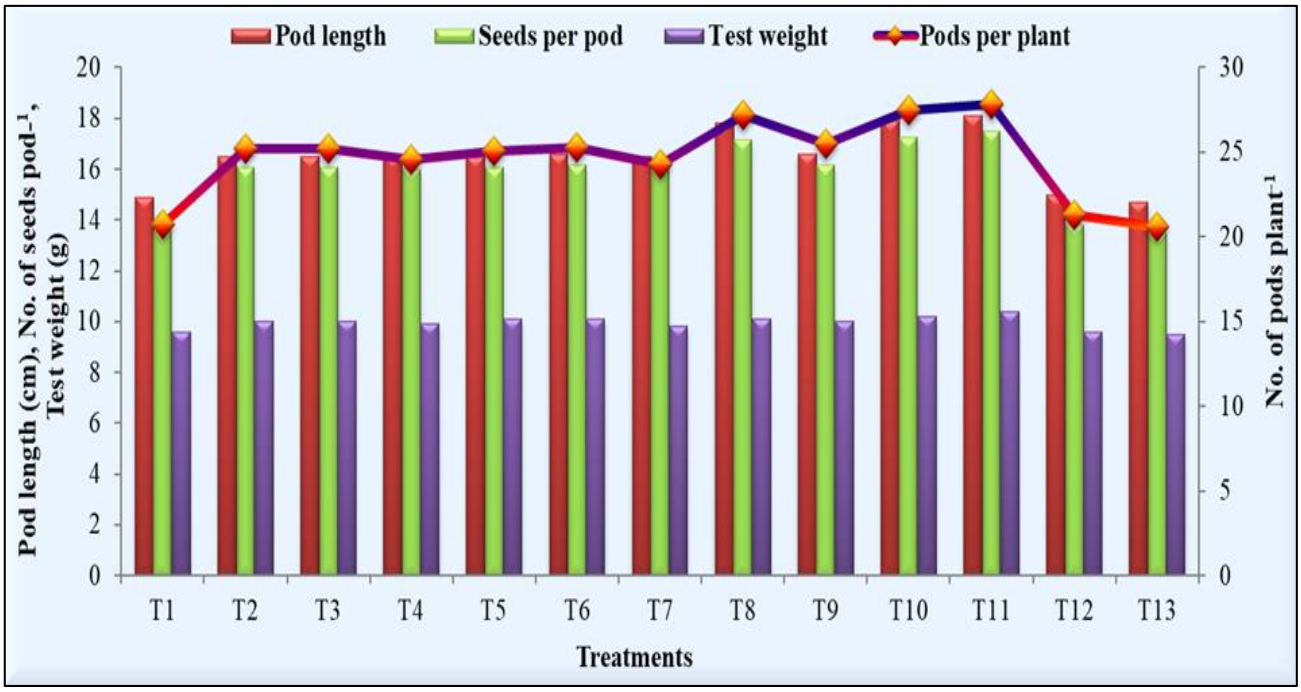

Fig 1: Yield attributes of cowpea influenced by foliar nutrition

T_1 : 100% RDF (Control)
T_2 : 100% RDF + 2% DAP at 40 DAS
T_3 : 100% RDF + 2% Pulse magic at 40 DAS
T_4 : 100% RDF + 0.2% Ampoxicilin at 40 DAS
T_5 : 75% RDF + 2% DAP at 40 DAS
T_6 : 75% RDF + 2% Pulse magic at 40 DAS
T_7 : 75% RDF + 0.2% Ampoxicilin at 40 DAS
T_8 : 75% RDF + 2% DAP + 2% Pulse magic at 40 DAS
T_9 : 75% RDF + 2% DAP + 0.2% Ampoxicilin at 40 DAS
T_{10} : 75% RDF + 2% Pulse magic + 0.2% Ampoxicilin at 40 DAS
T_{11} : 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxicilin at 40 DAS
T_{12} : 100% RDF + Water spray
T_{13} : 75% RDF + Water spray

Table 4: Influence of foliar nutrition on yield attributes and yield of cowpea

Treatments	No. of pods plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	20.7	14.9	13.6	9.6	869	2172
T_2	25.2	16.5	16.1	10.0	1135	2813
T_3	25.2	16.5	16.1	10.0	1141	2820
T_4	24.6	16.5	16.0	9.9	1102	2634
T_5	25.1	16.5	16.1	10.1	1126	2763
T_6	25.3	16.6	16.2	10.1	1149	2823
T_7	24.3	16.5	16.0	9.8	1084	2580
T_8	27.2	17.8	17.2	10.1	1271	3101
T_9	25.5	16.6	16.2	10.0	1160	2868
T_{10}	27.5	17.9	17.3	10.2	1285	3231
T_{11}	27.8	18.1	17.5	10.4	1357	3550
T_{12}	21.3	15.0	13.8	9.7	872	2204
T_{13}	20.6	14.7	13.5	9.5	859	2153
S. Em. ±	0.7	0.5	0.5	0.2	52	168
C.D. (P=0.05)	2.1	1.4	1.3	NS	151	489

T_1 : 100% RDF (Control)
T_2 : 100% RDF + 2% DAP at 40 DAS
T_3 : 100% RDF + 2% Pulse magic at 40 DAS
T_4 : 100% RDF + 0.2% Ampoxicilin at 40 DAS
T_5 : 75% RDF + 2% DAP at 40 DAS
T_6 : 75% RDF + 2% Pulse magic at 40 DAS
T_7 : 75% RDF + 0.2% Ampoxicilin at 40 DAS
T_8 : 75% RDF + 2% DAP + 2% Pulse magic at 40 DAS
T_9 : 75% RDF + 2% DAP + 0.2% Ampoxicilin at 40 DAS
T_{10} : 75% RDF + 2% Pulse magic + 0.2% Ampoxicilin at 40 DAS
T_{11} : 75% RDF + 2% DAP + 2% Pulse magic + 0.2% Ampoxicilin at 40 DAS
T_{12} : 100% RDF + Water spray
T_{13} : 75% RDF + Water spray

Summary
Application of 75% RDF + 2% DAPS + 2% Pulse magic + 0.2% Ampoxicilin recorded higher growth indices, yield attributes and yield of cowpea. Foliar application of 2% DAP + 2% Pulse magic + 0.2% Ampoxicilin along with 75% RDF resulted into 57 per cent increase in grain yield (1357kg ha^{-1}) over 75% RDF alone (859 kg ha^{-1}) besides reduction in required fertilizers and cost of cultivation.

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