Influence of urea foliar nutrition and leaf harvesting intensity on growth, yield attributes and yield in cowpea [*Vignaunguiculta*(L.) Walp.]

Abstract

A field experiment was undertaken at Farming Systems Research Station (FSRS), Sadanandapuram, Kollam district, Kerala Agricultural University in*summer* 2022 for studying the effect of growth, yield attributes and yield of cowpea through foliar application of 2% urea and intensity of leaf harvesting. Experimental treatments comprisedof 4 levels of foliar nutrition management (2% urea spray at vegetative stage (f_1), 2% urea spray at flowering stage (f_2), 2% urea spray at vegetative stage and flowering stage (f_3), water spray control (f_4) and 3 levels of leaf harvest(20% leaf harvest (l_1), 40% leaf harvest (l_2), and no leaf harvest (l_3). Among the foliar nutrition management treatments, f_3 showed significantly the taller plants (91.97 cm), more number of branches (15.13), leaves (34.76), leaf area/ plant (884.29 cm2), leaf area index (1.96) dry matter production (42.39 g) and chlorophyll content (3.544 mg/g) and were comparable with f_1. The nodule parameters such as nodule number (37.44) and effective number of nodules (32.11) were the highest in treatment f_3 and was on par with f_1. Further, days to 50 per cent flowering (53.65 days), pod length (17.27 cm), 100 seed weight (12.40 g), pod number (24.58), foliage yield (1484.57 kg ha^{-1}), grain yield (925.85 kg ha^{-1}) and haulm yield (2722.70 kg ha^{-1}) were the highest in treatment f_3 and was on par with f_1 except for pod weight (21.19 g). Among the leaf harvest intensity, treatment l_3 recorded the taller plants (92.45 cm), leaf area per plant (902.71cm^2) leaf area index (2.01), less days to 50% flowering (47.60 days) and haulm yield (2754.85 kg ha^{-1}). It was on par with l_1 pertaining to plant height. The number of branches (15.03), dry matter production per plant (40.78g), pod weight/plant (19.43 g), pod number/plant (23.59) and grain yield (925.85 kg ha^{-1}) were the highest in treatment l_1.

Key words: cowpea, foliar nutrition, leaf harvesting intensity growth attribute, yield, yield attributes, nodule parameters

1. INTRODUCTION

Cowpea (*Vignaunguiculata* (L.) Walp.)is a crop that can be used in many ways. It gives a good amount of protein, and its seeds can be eaten as pulses. Its leaves and green pods can be eaten as vegetables. Pulses and vegetables from cowpea can help as tonics, appetizers, stimulants, aphrodisiacs and anthelmintics. Cowpea leaf has 4.2 g protein, 110 mg calcium, 4.7 mg iron, 383.2 mg phosphorus, 12.91 mg zinc, 2.4 mg beta-carotene, 35 mg ascorbic acid and 34 calories of energy in each serving[1]. Cowpea leaves can be used for human and animal food. They have many micronutrients, natural compounds and antioxidants. Some of the antioxidants in the leaves are alpha tocopherols, flavonoids and lycopenewhich are substances that fight cancer[2]. In addition, increasing the output of cowpea requires balanced recommended dose of fertilizers. Along with recommended dose of fertilizer (RDF), additional nourishment foliar application of fertilizers might increase the use efficiency fertilizers[28-31].

Foliar fertilizationis gaining importance in plant nutrition during these days. Folia application is regarded as a preferred solution when quick supply of nutrition is hindered or the soil conditionsneed to be more conducive to the absorption of nutrients. The plants take in the fertilizer through their micropores on the leaves. Obliviously the foliar fertilization reduces the amount of fertilizers used. This experiment was conducted to study the effect of growth, growth attributes, yield attributes and yield of cowpea through foliar application of 2% urea and intensity of leaf harvesting.

2. MATERIALS AND METHODS

The study was conducted in the field of Farming Systems Research Station (FSRS), Sadanandapuram, Kollam district, Kerala, which is situated at 8.9815° N latitude and 76.8109° E longitude, comes under southern zone of Kerala during *summer* 2022.Experimental treatments comprised of 4 levels of foliar nutrition management (2% urea spray at vegetative stage (f_1), 2% urea spray at flowering stage (f_2), 2% urea spray at vegetative stage and flowering stage (f_3), water spray control (f_4) and 3 levels of leaf harvest (20% leaf harvest (l_1), 40% leaf harvest (l_2), and no leaf harvest (l_3). Design used for the experiment was RBD replicated thrice. The soil in the experiment site was acidic in nature (pH: 4.34) and sandy loam in nature. Electrical

conductivity of soil is very low (0.16). The nutrient status showed that the available nitrogen estimated by alkaline permanganate method [3], phosphorus by Dickman and Brays molybdenum blue method using spectrophotometer [4] and potassium by ammonium acetate method [4]. The nutrient content were 286 kg ha^{-1}, 13 kg ha^{-1} and 151 respectively. The crop was raised as per package of practices of Kerala Agricultural University. The crop was applied with RDF 20: 30: 10 kg N: P_2O_5: K_2O. The genotype used for the experiment was DCS – 47(1), which was released from University of Agricultural Science, Dharwad, Karnataka. The seeds were sown at a spacing of 30 cm x 15 cm. The fully opened leaves from the top were harvested at 31 days after sowing. Total chlorophyll content of harvested were determined using dimethyl sulfoxide method[5] and expressed in mg g^{-1} fresh weight. The crop was harvested on 75 DAS and growth parameters, yield parameters and nodulation parameters were recorded and statistically analyzed.

3. RESULTS AND DISCUSSION

3.1 Effect of urea foliar nutrition on growth attributes of cowpea

3.1.1Plant height

Taller plants were found to be in treatment f_1 (spraying during the vegetative stage) (70.50 cm), which was statistically similar to f_3 (spraying atvegetative and flowering stages)(69.21 cm) at 40 DAS (Days after sowing) (Table1). On the other hand, f_3 (spray during vegetative and flowering stage) exhibited taller plants (91.97 cm) at harvest and were comparable with f_1 (urea spray at vegetative stage) (88.22 cm) and f_2 (urea spray during flowering stage) (87.98 cm). Due to the reason that the treatments received additional application of urea through foliar spray during vegetative stage which might have caused an increase in the photosynthetic activity of the plant, intensification of metabolic activity and efficient utilisation of nitrogen. [6] also reported that the spraying of 2 per cent urea increased the plant height and the number of branches.

3.1.2 Number of branches per plant

The quantity of branches produced was greatly affected by foliar treatment. F_3 (urea spray at vegetative and flowering stage) reached considerably more branches per plant (12.61

and 15.13, respectively) at 40 DAS and at harvest, and it was comparable to treatment f_1 (urea spray at vegetative stage) (12.43 and 14.71, respectively) (Table1). On the other hand, at 40 DAS (10.16) and harvest (11.97), fewer branches were seen in the treatment water spray (f_4). Due to the additional application of urea through foliar spray during vegetative stage which might have caused an increase in the photosynthetic activity of the plant, intensification of metabolic activity and efficient utilization of nitrogen and supported with findings of [6].

3.1.3 Number of leaves per plant

Higher number of leaves per plant was recorded with f_3 (urea spray at vegetative and flowering stage) (26.45 and 34.76 respectively at 40 DAS and harvest) which found to be on par with f_1(urea spray during vegetative stage)at 40 DAS andharvest (25.45 and 33.44 respectively) (Table1). Plants in f_4 (water spray) had the lesser number leaves per plant, with 20.26 at 40 DAS and 28.50 atharvest.This could be due to increased branching and leaf size brought on by the foliar application of urea, which resulted in more leaf area per plant and a higher leaf area index. The results are in agreement with [7] who reported that the leaf area per plant, the number of leaves and leaf area index increased with 2 per cent urea spray in cowpea.

3.1.4 Leaf area per plant

The amount of leaf area per plant was significantly enhanced by the urea spray applied on the leaves (Table1). At 40 days and harvest, the treatment f_3 (urea spray at vegetative and flowering stage) showed the maximum leaf area per plant (1412.52 and 884.29 cm^2, respectively), and this was comparable to f_1 (urea spray at vegetative stage) (1390.84 and 844.81 cm^2, respectively). In f_4 (water spray), the lowest leaf area was observed to be 1017.67 cm^2 at 40 DAS and 653.68 cm^2 at harvest.

3.1.5 Leaf area index

The f_3 urea spray at the vegetative and flowering stages recorded the greaterleaf area index (3.14 and 1.96 respectively) and was comparable to the f_1(urea spray at the vegetative stage) (3.09 and 1.88, respectively) at 40 DAS and at harvest (Table1). Treatment F_4 (water spray) was seen to have the considerably lowest leaf area index (2.26 and 1.45, respectively) at 40 DAS and at harvest.

3.1.6 Dry matter production per plant

The dry matter output per plant at 40 DAS (24.86 g plant^{-1}) was substantially greater for foliar treatments f_1 (urea spray at vegetative stage) and was comparable to f_3 (24.33 g plant^{-1}) (Table1). On the other hand, during harvest, treatment f_3 (urea spray at vegetative and flowering stages) produced higher amount of dry matter (42.39 g plant^{-1}), which was comparable to treatment f_1 (41.46 g plant^{-1}). Control treatment f_4 (water spray) had the lowest dry matter (34.27 g plant^{-1}) at harvest. This might be due to the higher branching, production of new leaves and delayed leaf senescence by an improved production of cytokinin from the foliar applied nitrogen sprayed at both vegetative and flowering stages, which ultimately increased the accumulation of dry matter in plant stems, leaves, roots of the plant. [8] also reported that 2 per cent foliar application of urea at 60 and 75 DAS significantly increased the dry matter accumulation per plant.

3.2 Effect of urea foliar nutrition on yield attributes and yield of cowpea

3.2.1 Days to 50 per cent flowering

Among the foliar applications, the water spray treatment (f_4 , control) blossomed earlier (45.40 days)and more often, in f_3 (urea 2% spray during vegetative and flowering phases), a greater number of days to 50% flowering was observed (53.65 days) (Table2). This may be the result of nitrogen's strong impact on growing plant development traits, which may be caused by improved protein synthesis and metabolite transport. This accelerated photosynthesis and cell division, increasing vegetative growth and ultimately delayed the days to 50% of the plants flowered [9].

3.2.2Number of pods per plant

The greater pod number was obtained by urea spray during the vegetative and flowering stage (f_3)(24.59) and it was on par to urea spray at the vegetative stage (f_1) (23.62) (Table2) (Fig. 1). Foliar application of urea significantly increased number of pods in comparison to control treatment. There were more branches, a higher photosynthetic efficiency—achieved by delaying leaf senescence, improving photosynthate translocation to the pods, direct nitrogen application, and increased nutrient absorption—which resulted in an immediate nitrogen supply and reduced flower drop in comparison to the control treatment. All of these factors contributed to the higher

number of pods per plant. [10]observed similar outcomes that foliar application ofurea enhanced the number of pods.

3.2.3 Pod length

Pod length was observed to be considerably greater for plants treated with urea 2 per cent during the vegetative and flowering stages (17.27 cm) (f_3) (13.74 cm) and was comparable to treatment urea 2 per cent during the flowering stage (f_2) (16.0 cm)(Table2) (Fig. 1). This might be due to mobility of more photosynthates into the pods, which causes seed filling to lengthen the pods. The length of the pod was also reported to be enhanced by urea spray [11].

3.2.4Average pod weight

The significant highest pod weight registered with treatment 2% urea spray at vegetative and flowering stage(f_3) (21.19 g)(Table2) (Fig. 1). Treatment f_4 (water spray) had the lowest pod weight (13.89 g). More pods were produced by the urea spray, which was linked to the increased number of secondary branches. It's possible that the extra nitrogen supplement enhanced seed fullness in pods formed on secondary branches. These results were on line with [12] who showed that urea spray increased the pod weight.

3.2.5 Hundred seed weight

Urea foliar treatment 2 per cent resulted in a significant impact on test weight (Table2). The treatment f_3 (spraying during the vegetative and flowering stages) weighed 12.41 g, which were comparable with 2% urea spray at vegetative and flowering stage (f_2) (12.32 g) and 2% urea spray at vegetative and flowering stage (f_1) (12.04 g). The enhancement in seed weight may be caused by the removal of total cytokinin and minerals from this source as a result of a shift in the flow of cytokinin and mineral nutrients from the roots, which typically gets reduced during the pod filling stage [13].

3.2.6 Number of green leaves harvested per plant

Spraying urea during the vegetative stage (f_1) produced a significantly greater number of leaves collected per plant (10.07), which was on par to f_3 (9.94). In the water spraytreatment(f_4), the lowest number leaves (7.77) were nipped off per plant.Foliar application of nitrogen to the

plant in addition to the recommended amount of fertilizer might had accelerated the plant's vegetative development and increased the amount of leaves production by each plant.

3.2.7 Foliage yield

Spraying 2%urea at vegetative and flowering stage resulted a significant greater leaf yield (f_3) (1484.57 kg ha^{-1}), which was on par with spraying at the vegetative stage (f_1) (1452.32 kg ha^{-1}) (Table2) (Fig. 2). Water spray (f_4) produced the lowest leaf yield (1160.83 kg ha^{-}). Greater yield of foliage might be due to production of vegetative growth which accelerated by foliar supply of nitrogen,

3.2.8 Grain yield

Foliar application of 2% urea at vegetative and flowering stage (f_3) resulted significant enhancement of grain yield (925.85 kg ha^{-1}) which was comparable to the grain yield of spraying 2% urea during the vegetative stage (f_1) 912.84 kg ha^{-1}(Table2) (Fig. 2). Greater foliage, grain yield might be the outcome of foliar supply of nitrogen which boosted the production of flowers and fruiting bodies [14]. Because of the growth regulator ABA, this may have lessened the shedding of flowers and fruits, resulting in a positive source-sink gradient of photosynthates. It's possible that more nitrogen delivered delayed the leaves' senescence and enhanced overall absorption and carbon remobilization to the seeds of succeeding pods in treatment f_3. A study by [15] reported that urea application at vegetative and flowering stages increased the grain yield.

3.2.9 Haulm yield

The maximum haulm production (2722.70 kg ha^{-1}) was achieved with foliar spray during the vegetative and flowering phases (f_3) (Table2) (Fig. 2). On the other hand, f_4 (water spray) had the lowest haulm yield, measuring 2191.88 kg ha^{-1}.Possible causes for this included prolonged vegetative development, which led to an increase in plant height, branching, and leaf area per plant.

3.2.10 Harvest index

Foliar application of 2% urea at vegetative (f_1) resulted greatest harvest index (0.36) which were comparable with foliar spray during the vegetative and flowering phases (f_2) (0.35) and with foliar spray during the vegetative and flowering phases (f_3) (0.35) (Table2). This may be because foliar application of urea promoted growth and improved photosynthetic product translocation to the economic portion of the plant.

3.3Effect of urea foliar nutrition on chlorophyll content and nodulation parameters of cowpea

3.3.1 Chlorophyll content

Significant impact was perceived by foliar application of urea (Table3). A significantly higher chlorophyll content (3.56 mg g^{-1}) was observed in treatment f_3 (urea spray at vegetative and flowering stage), which was comparable to treatment f_1 (urea spray at vegetative stage) (3.54 mg g^{-1}). This could be attributed to the effect of nitrogen as a component of chlorophyll. Applying urea to the plant foliage surface leads to the easy absorption and lead to increases the availability of nitrogen in the plant, which could upsurge the chlorophyll content in the plant leaf. Results reported by [16] hasalso showed that spraying urea increased the chlorophyll content.

3.3.2 Number of nodules per plant

In the context of foliar management treatments, treatment f_3 (urea spray at vegetative and flowering stage) had the maximum number of nodules (37.44), which was comparable to treatment f_1 (urea spray at vegetative stage) (37.00) (Table3). Control treatment f_4 (water spray) had the lowest nodule number (32.11) of any treatment.

3.3.3 Number of effective nodules per plant

Among the different foliar nutrition management treatments, urea spray during vegetative and flowering stage(f_3) was showed considerably higher effective nodule number (32.11) and comparable with f_1(urea spray at vegetative stage) (31.67) (Table3). For the treatment control, f_4 (water spray) had the fewest effective nodules (26.78).

3.3.4 Fresh weight of nodules

The treatment f_1 (urea spray in vegetative stage) had the greater fresh weight of nodules (966.72 mg), which were comparable with f_3 (urea spray at vegetative and flowering stage) (965.77 mg) and f_2 (urea spray at flowering stage) (911.39 mg) (Table3). The control treatment recorded lowest fresh nodule weight (870.19 mg).

3.4 Effect of leaf harvesting intensity on growth attributes of cowpea

3.4.1Plant height

The effect of intensity of leaf harvesting on the plant height showed significant impact (Table 4). At 40 days, significantly taller plants (71.71 cm) were recorded in l_3 (no leaf harvest). At the time of crop harvest, plants in treatment l_3 (no leaf harvest) attained significantly higher plants (92.45 cm) and it was on par with leaf harvest at 20 per cent (l_1) (87.24 cm). The smallest plants were record in the treatment l_2 (40%leaf harvest) at both 40 DAS and at harvest (81.21 cm and 59.57 cm, respectively). The increase in plant height might be due to apical dominance which stimulated the plants to grow taller. Results observed by [17] concluded that no leaf harvest increased the height of the plant.

3.4.2 Number of branches per plant

The number of branches per plant varied significantly as a result of leaf harvesting (Table 4). At 40 DAS, the treatment l_3 (no leaf harvest) had much more branches (12.38), which was statistically comparable to the treatment l_1 (20% leaf harvest) (11.57). The treatment l_2 (40% leaf harvest) (10.67), which had the least branches. At harvest it was found that lowest at l_3 (no leaf harvest) (12.56) andstatistically greatest at l_1 (20% leaf harvest) (15.03). The reason behind it might be due to leaf harvesting of growing points or upper canopy reduces the apical dominance simultaneously and increases the meristem growth of the lateral branches. Leaf clipping at the vegetative stage creates more time to recover from the leaf loss and the same time creates a long time to increase the number of branches [18]. Results reported by [19] showed branching was improved even in the limited leaf harvest.

3.4.3 Number of green leaves per plant

The number of leaves per plant at 40 DAS dropped as leaf picking intensity increased (Table 4). Treatment l_2 (40% leaf harvest) recorded the lowest number of leaves (19.26), whereas treatment l_3 (no leaf harvest) achieved the maximum number of leaves (26.65). On the other hand, the opposite pattern was observed during harvest season. In treatment l_2, (40% leaf harvest) the greatest number of leaves were recorded (35.05), whereas in treatment l_3 (no leaf harvest) the least number of leaves were recorded (29.02). This might be due to harvesting leaves at 31 DAS increased branch nodes, which allowed for greater leafy growth in the 40 per cent leaf harvest treatment compared to other treatments.

3.4.4 Leaf area per plant

Leaf area per plant was significantly impacted by the intensity of leaf picking (Table 4). At 40 days and harvest, treatment l_3 (no leaf harvest) had the largest leaf area (1418.54 and 902.71 cm^2 respectively), whereas treatment l_2 (40% leaf harvest) had the lowest leaf area (1146.59 and 679.39 cm^2 respectively). This might be due to the reason that leaf harvesting resulted in the emergence of smallsized leaves instead of higher leaf size, thus expressed lower leaf area per plant and leaf area index. Results obtained in this study are in agreement with [20] who observed that leaf harvest caused a reduction in size of the leaves resulting in decreased leaf area index.

3.4.5 Leaf area index

Out of all the leaf harvest treatments, the plants that did not get any leaf harvest (l_3) had the best leaf area index (3.15 and 2.01), whereas the treatment with 40% leaf harvest (l_2) had significantly lowest leaf area index at 40 DAS (2.55) and harvest (1.51) (Table 4).

3.4.6 Dry matter production per plant

No leaf harvest (l_3) at 40 DAS showed noticeably higher dry matter (23.56 g $plant^{-1}$), which was comparable to l_1 (22.47 g $plant^{-1}$) (Table 4). When it came time to harvest, l_1 (20% leaf harvest) produced considerably more dry matter (40.78 g $plant^{-1}$) than control (l_3) (38.97 g $plant^{-1}$). The treatment l_2 (40% leaf harvest) had the lowest dry matter output at 40DAS (16.81 g $plant^{-1}$) and harvest (38.25 g $plant^{-1}$). This might be the result of more branching, higher translocation of photosynthates to the stems, higher number of pods and higher pod weight per

plant attained by limited leaf harvest. Likewise, [21] also observed that pinching at 25 DAS after sowing increases the dry matter production.

3.5 Effect of leaf harvesting intensity on yield attributes and yield of cowpea

3.5.1 Days to 50 per cent flowering

Among different leaf harvest, the treatment l_2, which received 40% of the leaves harvested, took longer to reach 50% flowering (50.46 days), whereas, treatment l_3, which had no leaf harvest, recorded early blooming (47.60 days) and was comparable to treatment l_1(49.95 days)(Table 5). This might be explained by the fact that during vegetative growth, leaves were harvested, resulting in a decrease of leaf area. This delayed the senescence of the remaining leaves, which in turn helped to produce photosynthates. The blooming process may have been delayed by an increase in leaf harvesting intensity, allowing for adequate plant height development, plant branching, and greater production of growth-promoting substances. Similarly, [22] results were also in line with the results in this experiment.

3.5.2 Number of pods per plant

The maximum pod number (23.59) was obtained with treatment l_1 (20% leaf harvest) compared to control (21.89) (Table 5)(Fig. 3), In the treatment l_2 (40% leaf harvest), the least pod number per plant (19.83) was recorded. The decrease in the number of pods produced per plant may be the result of a higher rate of foliage loss and the inability of the remaining leaves to grow normally, which leads to improper pod filling. A higher number of branches, restricted leaf harvesting, which enhanced the photosynthetic efficiency of the remaining leaves, more flowers being produced, and improved photosynthate translocation to new pods rather than to the older leaves could all be contributing factors to the higher number of pods. [23] found that there was a correlation between restricted leaf cutting and an increase in branches, which may indicate that there are more branches overall.

3.5.3 Average pod weight

In comparison to the control treatment (17.76 g), the treatment l_1 (20% leaf harvest) exhibited the highest pod weight per plant (19.43 g) (Table 5) (Fig. 3). The treatment l_2 (40% leaf harvest) showed significant lowest pod weight (16.02 g). The higher pod weight could be the

result of early-phase defoliation, which reduces competition for photosynthate translocation between vegetative sinks and reproductive sinks, and remaining leaves that can compensate for leaf losses through leaf harvest along with an increase in the number of productive pods. Additionally, [24] noted that plucking one or two leaves from the top portion of the plant and the basal leaves enhances the weight of the pods.

3.5.4 Number of green leaves harvested per plant

Significantly greatest number of leaves collected (11.93) per plant was observed with a 40% leaf harvest (l_2), whereas the treatment with 20% leaf harvest l_2 showed the lowest number of leaves harvested per plant (5.89) (Table 5).

3.5.5 Foliage yield

Higher leaf yield (2519.25 kg ha^{-1}) was obtained by treatment l_2 (40% leaf harvest) and proceeded by treatment l_1 (1430.18 kg ha^{-1}) (Table 5)(Fig. 4). In the control treatment (no leaf harvest; l_3), no leaves were taken (0.0 kg ha^{-1}).Higher number of leaves harvested per plant and foliage yield might be because more leaves were plucked from the plant. [25] also reported similar results in his study on cowpea.

3.5.6 Grain yield

A little intense leaf harvesting (20%)*i.e.*, treatment l_1, resulted significantly higher grain yield (876.48 kg ha^{-1})(Table 5) (Fig. 4).The control treatment (l_3) registered 850.23 kg ha^{-1}. In contrast, treatment l_2 (40% leaf harvesting) produced a lower grain yield (824.91 kg ha^{-1}).This might be as a result of having more branches, which offer greater space for the production of pods. A restricted amount of defoliation may have enabled those that remained leaves to intercept more light, delaying the senescence of the leaves and improving photosynthetic efficiency and photosynthates transfer to new pods on the plant. The results of the study conducted by [26] support the present study.

3.5.7 Haulm yield

The treatment with the lowest haulm yield (2225.95 kg ha^{-1}) among the leaf harvest intensities was treatment l_2 (40% leaf harvest), whereas treatment l_3 (control) had the highest

haulm output (2754.85 kg ha^{-1}) (Fig. 4) (Table 5). This might be because the plant's increased vegetative development produced more haulm produce. These findings confirmed with findings [27].

3.5.8 Harvest index

The degree of leaf harvesting has a major impact on the harvest index. 40% leaf harvest(l_2) had the greatest harvest index (0.370) (Table 5). This might be because more photosynthates were sent to the leaves that already existed, producing additional leaves without significantly lowering grain output.

3.6 Effect of leaf harvesting intensity on chlorophyll content and nodulation parameters of cowpea

It was observed thatcholorophyll content of harvested leaves, number of nodules, effective nodules and nodule fresh weights were not significantly influenced by the leaf harvesting intensity (Table 6).

4. CONCLUSION

Foliar application of 2% urea at vegetative stage and flowering stage recorded higher growth, yield attributes, grain yield, foliage yield, chlorophyll content in the leaves and nodule parameters such as nodule number and effective number of nodules which were comparable with 2% urea spray at vegetative stage. Among the leaf harvest intensity, the plants which are not subjected to leaf harvest registered the taller plants, leaf area per plant ,leaf area index, less days to 50% flowering and haulm yield . But the number of branches, dry matter production per plant, pod weight/plant, pod number/plant and grain yield were the highest when plant subjected to 20 % leaf harvest in cowpea.

Table 1. Effect of foliar nutrition on growth attributes of cowpea

Treatments	Plant height (cm)			No. of branches			No. of leaves plant^{-1}			Leaf area plant $^{-1}$ (cm^2)			Leaf area index			Dry matter production (g plant^{-1})		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
f_1	29.96	70.50	88.22	4.67	12.43	14.71	16.07	25.45	33.44	352.26	1390.84	844.81	0.78	3.09	1.88	3.55	24.86	41.46
f_2	30.84	61.95	87.98	4.41	10.97	13.49	15.58	20.41	31.20	347.07	1322.67	799.20	0.77	2.94	1.78	3.95	17.02	39.21
f_3	31.33	69.21	91.97	4.63	12.61	15.13	15.83	26.45	34.76	354.58	1412.52	884.29	0.79	3.14	1.97	3.78	24.33	42.40
f_4	30.30	58.92	79.70	4.70	10.16	11.97	16.08	20.26	28.50	361.97	1017.67	653.68	0.80	2.26	1.45	3.62	17.58	34.27
SE (m) ±	0.51	1.11	2.32	0.13	0.33	0.24	0.42	0.89	1.12	7.12	21.70	13.83	0.02	0.05	0.03	0.22	0.52	0.41
CD (0.05)	NS	3.25	6.81	NS	0.98	0.71	NS	2.61	3.29	NS	63.64	40.56	NS	0.14	0.09	NS	1.52	1.21

(f_1: urea 2% spray at vegetative stage, f_2: urea 2% spray at flowering stage, f_3: urea 2% spray at vegetative and flowering stage, f_4: control water spray)

Table 2. Effects of foliar nutrition on yield attributes and yield of cowpea

Treatments	Days to 50% flowering	No. of pods plant^{-1}	Average pod length (cm)	Average pod weight (g)	100 seed weight (g)	No. of green leaves harvested plant^{-1}	foliage yield (kg ha^{-1})	Grain yield (kg ha^{-1})	haulm yield (kg ha^{-1})	Harvest index
f_1	49.75	23.62	15.64	18.82	12.04	10.07	1452.32	912.84	2575.81	0.36
f_2	48.55	20.73	16.00	17.04	12.32	7.87	1168.18	887.77	2545.61	0.35
f_3	53.65	24.59	17.27	21.19	12.41	9.94	1484.57	925.85	2722.70	0.35
f_4	45.40	18.14	13.47	13.90	10.67	7.77	1160.83	675.69	2191.88	0.31
SE (m) ±	0.86	0.34	0.53	0.51	0.40	0.21	38.04	9.92	33.77	0.01

CD (0.05)	2.52	0.99	1.54	1.48	1.18	0.64	111.58	29.10	99.05	0.01

(f_1: urea 2% spray at vegetative stage, f_2: urea 2% spray at flowering stage, f_3: urea 2% spray at vegetative and flowering stage, f_4: control water spray)

Table 3. Effect of foliar application on chlorophyll content and nodule parameters of cowpea

Treatments	Chlorophyll content in harvested leaves (mg g^{-1})	No. of nodules $plant^{-1}$	No. of effective nodules $plant^{-1}$	Nodules fresh weight $plant^{-1}$ (mg)
f_1	3.54	37.00	31.67	966.72
f_2	2.67	33.78	28.44	911.39
f_3	3.56	37.44	32.11	965.77
f_4	2.59	32.11	26.78	870.19
SE (m) ±	0.01	0.64	0.90	22.24
CD (0.05)	0.334	1.87	2.64	65.22

(f_1: urea 2% spray at vegetative stage, f_2: urea 2% spray at flowering stage, f_3: urea 2% spray at vegetative and flowering stage, f_4: control water spray)

Table 4. Effect of leaf harvesting intensity on growth attributes of cowpea

Treatments	Plant height (cm)			Number of branches			Number of leaves $plant^{-1}$			Leaf area $plant^{-1}$ (cm^2)			Leaf area index			Dry matter production g $plant^{-1}$		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
l_1	30.25	64.16	87.24	4.81	11.57	15.03	15.93	23.53	31.86	351.43	1292.64	804.38	0.78	2.87	1.79	3.86	22.47	40.78
l_2	31.09	59.57	81.21	4.39	10.68	13.89	16.08	19.26	35.05	359.22	1146.59	679.39	0.80	2.55	1.51	3.72	16.81	38.25
l_3	30.49	71.71	92.45	4.61	12.38	12.56	15.66	26.65	29.03	351.26	1418.54	902.71	0.78	3.15	2.01	3.60	23.56	38.97
SE (m) ±	0.44	0.96	2.01	0.11	0.29	0.21	0.37	0.77	0.97	6.16	18.79	11.98	0.01	0.04	0.03	0.19	0.45	0.36

CD (0.05)	NS	2.81	5.90	NS	0.85	0.62	NS	2.26	2.85	NS	55.12	35.12	NS	0.12	0.08	NS	1.32	1.05

(l_1: 20% leaf harvest, l_2: 40% leaf harvest, l_3: control - no leaf harvest)

Table 5. Effect of leaf harvesting intensity on yield attributes and yield of cowpea

Treatments	Days to 50% flowering	No. of pods plant^{-1}	Average pod length (cm)	Average pod weight (g)	100 seed weight (g)	No. of green leaves harvested plant^{-1}	foliage yield (kg ha^{-1})	grain yield (kg ha^{-1})	haulm yield (kg ha^{-1})	Harvest index
l_1	49.96	23.59	16.10	19.43	11.58	5.89	1430.18	876.48	2546.20	0.34
l_2	50.47	19.83	15.02	16.02	11.86	11.93	2519.26	824.91	2225.95	0.37
l_3	47.60	21.89	15.67	17.76	12.13	--	0.00	850.23	2754.85	0.31
SE (m) ±	0.74	0.29	0.46	0.44	0.35	0.15	32.95	8.59	29.25	0.01
CD (0.05)	2.18	0.86	NS	1.28	NS	0.45	96.63	25.20	85.78	0.01

(l_1: 20% leaf harvest, l_2: 40% leaf harvest, l_3: control - no leaf harvest)

Table 6. Effect of leaf harvesting intensity on chlorophyll content and nodule parameters of cowpea

Treatments	Chlorophyll content in harvested leaves (mg g^{-1})	No. of nodules plant plant^{-1}	No. of effective nodules plant^{-1}	Nodules fresh weight plant^{-1} (mg)
l_1	3.078	35.08	29.75	927.39
l_2	3.086	34.75	29.42	902.56
l_3	3.022	35.42	30.08	955.60
SE (m) ±	0.098	0.55	0.78	19.26
CD (0.05)	NS	NS	NS	NS

(l_1: 20% leaf harvest, l_2: 40% leaf harvest, l_3: control - no leaf harvest)

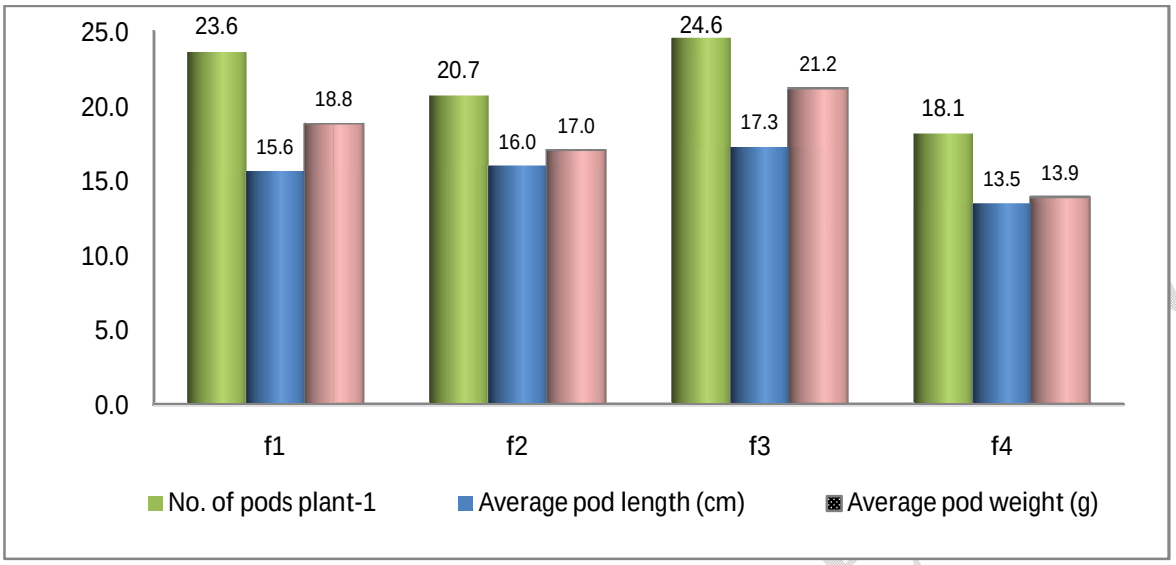

Fig. 1 Effect of foliar application of urea on number of pods, average length and average weight.

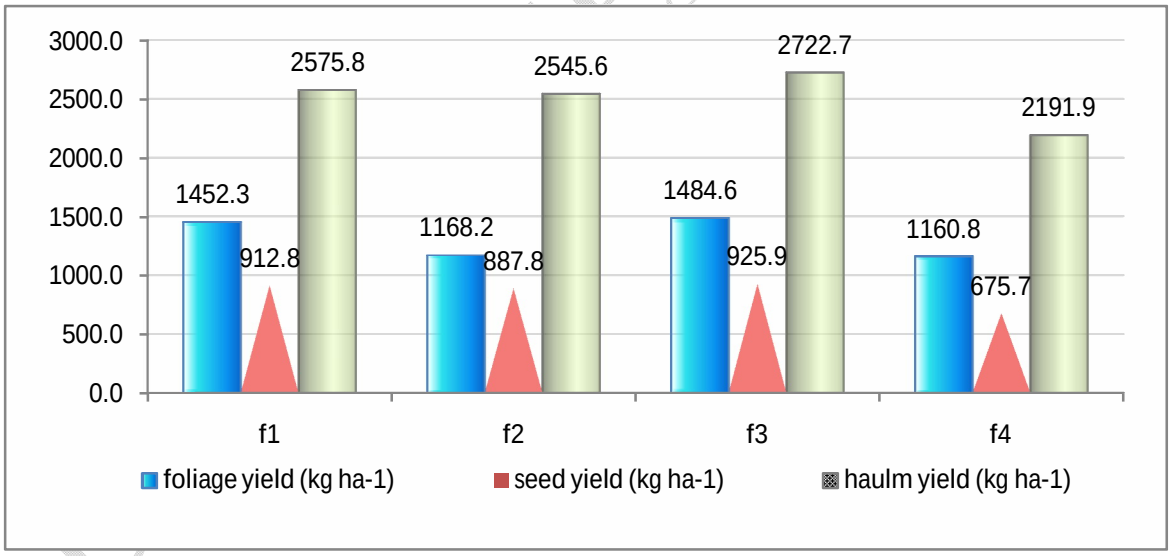

Fig. 2. Effect of foliar application of urea on foliage yield, grain yield and haulm yield

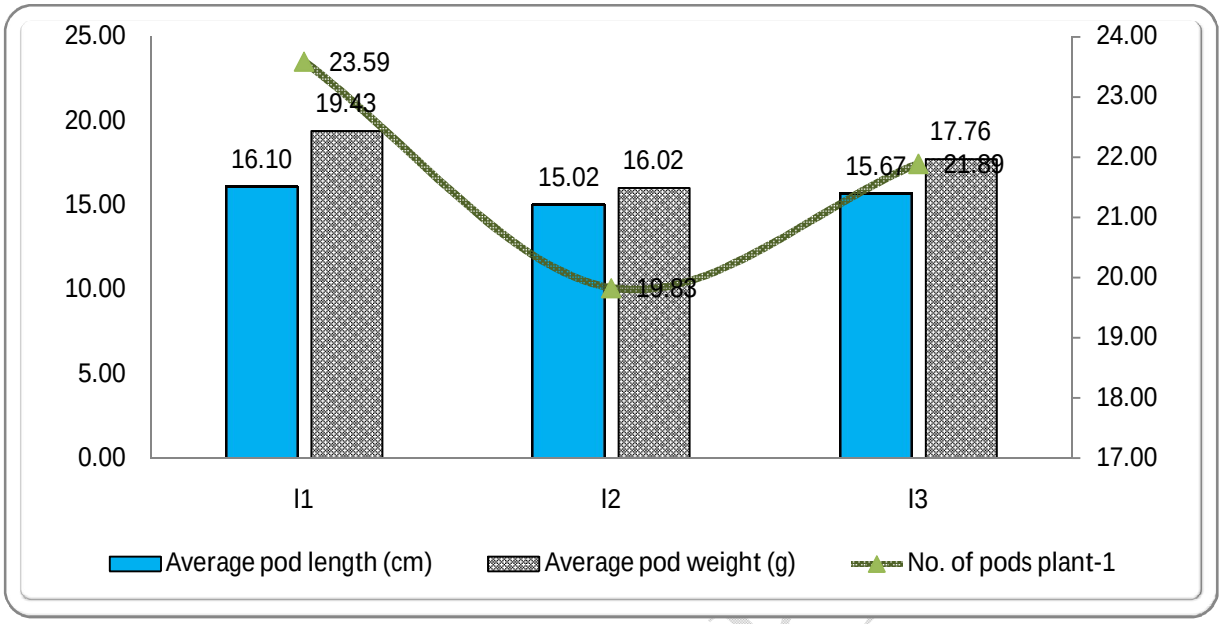

Fig. 3 Effect of leaf harvesting intensity on number of pods, average length and average weight

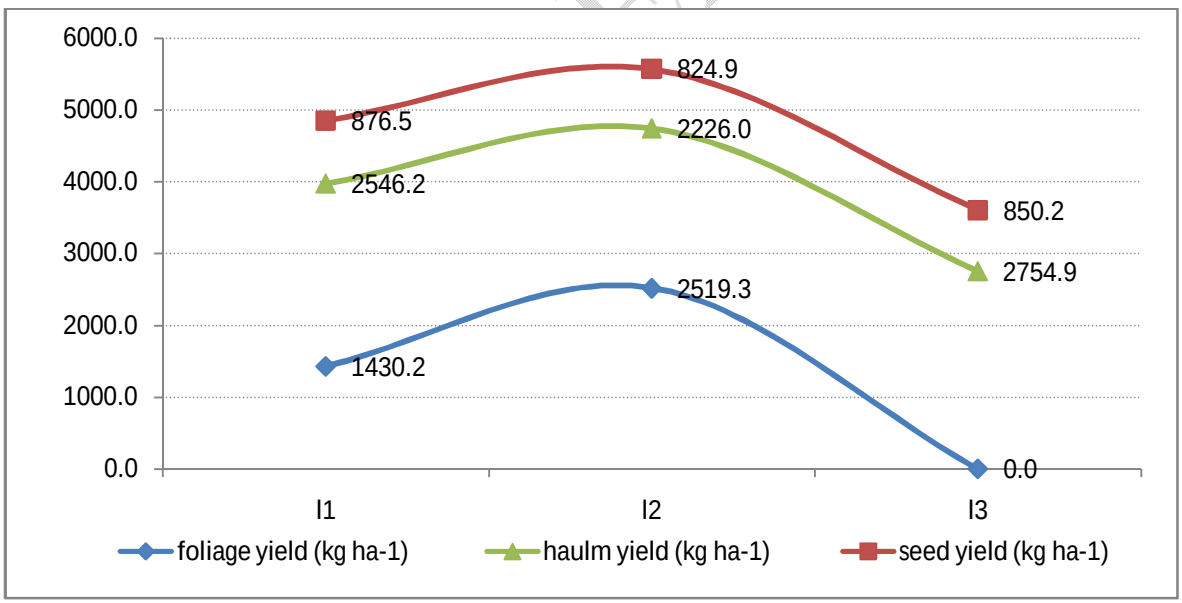

Fig. 4. Effect of leaf harvesting intensity on foliage yield, grain yield and haulm yield

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