Research Journal of Agricultural Sciences
An International Journal
www.rjas.org

Res. Jr. of Agril. Sci. 12(1): 82–85

P- ISSN: 0976-1675 | E- ISSN: 2229-4538

Research Paper

Response of Cowpea (*Vigna unguiculata* (L.) Walp) to Magnesium Nutrition in Lateritic Soils of Kerala

V. P. Soniya*, P. S. Bhindhu and P. Sureshkumar

Received: 26 Oct 2020 | Revised accepted: 16 Dec 2020 | Published online: 04 Jan 2021

ABSTRACT

Crop nutrient response information is important for fertilizer use decisions aimed at higher profitability but such information is limited with respect to cowpea cultivation. A pot culture experiment was conducted to study the response of cowpea towards magnesium fertilization in lateritic soils of Kerala during January 2019. Graded doses of magnesium were applied @ 5 mg kg^{-1} to 80 mg kg^{-1} of soil along with recommended dose of fertilizers. The effect of magnesium on content and uptake of essential nutrients and biometric parameters of cowpea were determined during flowering and at harvest of the crop. Graded doses of magnesium created significant variation in the accumulation of potassium, calcium and magnesium in stem and leaf of cowpea at both stages of analysis. Magnesium content in stem and leaf was found to increase with the levels of magnesium added. No significant variation in the content of calcium and magnesium in pods was recorded. Crop uptake of calcium (261.65 mg g^{-1}) and magnesium (66.62 mg g^{-1}), yield per plant (79.33 g $plant^{-1}$) and yield contributing characteristics were superior in the treatment where magnesium was applied @ 10 mg kg^{-1} of soil which suggests to be the optimum dose of magnesium to achieve maximum crop response of cowpea.

Key words: Cowpea, Magnesium carbonate, Plant nutrient content, Nutrient uptake, Yield

Cowpea (*Vigna Unguiculata* (L.) Walp), an annual herbaceous legume is an important food crop of Kerala that can be grown throughout the year. Apart from sole cropping, cowpea can be grown as a floor crop in coconut gardens, as intercrop in tapioca during May – September and as double crop in rice fallows during rabi and summer seasons [1]. Cowpea leaves and green pods are consumed as vegetables and dried grains are also used in various food preparations. It is also an important component of traditional cropping systems because it is an easily available, cheap source of protein for households and its contribution to soil fertility through biological nitrogen fixation. Roots of leguminous plants have higher cation exchange capacity than graminaceous plants. They require higher proportion of basic cations in their nutrition compared to grasses. In addition, calcium and magnesium are essential elements for efficient nitrogen fixation by rhizobia and magnesium deficiency results in reduced nitrogen fixation [2]. Leguminous crops respond well to magnesium nutrition in terms of both crop quality and quantity. Soil application of magnesium increased the growth of plants and better root nodulation in ground nut [3]. Improved shoot and root dry matter yield in green gram (*Vigna radiata* L) as a result of dolomite application [4]. The use of magnesium sulphate for seed dressing and for foliar spray increased plant height, pods per plant, seeds per pod, thousand seed weight and fresh seed weight in pea [5].

*V. P. Soniya
soniyachandran95@gmail.com

[1-3]Radiotracer Laboratory, College of Horticulture, Vellanikkara, Thrissur - 680 656, Kerala, India

Lateritic soils occupy more than 50 per cent of the total geographical area of Kerala [6] and are characterized by low pH, low cation exchange capacity, low effective cation exchange capacity and base saturation, with dominant presence of 1:1 type clay mineral [7]. Magnesium deficiency is a common nutritional disorder in these soils. Magnesium fertilization is the effective strategy to combat deficiency issues. But correction of magnesium deficiency with widely used highly soluble source like magnesium sulphate introduces leaching problems. So comparatively less soluble magnesium carbonate was tried in this experiment. Studying the response of cowpea towards different dose of magnesium will help to optimize magnesium nutrition for maximum yield and quality.

MATERIALS AND METHODS

A pot culture experiment was conducted at Radiotracer Laboratory, College of Horticulture, Kerala Agricultural University during January, 2019 to investigate the effect of magnesium nutrition on cowpea. Bush cowpea variety Bhagyalakshmi was used in the study. Top soil (0-15 cm depth) representing lateritic origin was collected, air dried, ground with wooden mortar and pestle, sieved through 2 mm sieve and characterized for available nutrient content. After initial characterization the texture of soil was found as sandy clay and with a pH of 4.70 which belongs to very strongly acidic category. Organic carbon (1.32%), available nitrogen (476.67 kg ha^{-1}) and potassium (240.18 kg ha^{-1}) were medium in status while phosphorus (98.04 kg ha^{-1}) was high. The secondary and micronutrients except magnesium (64.53 mg kg^{-1}) and boron (0.22 mg kg^{-1}) were sufficient. The experiment was conducted with twelve treatments viz. absolute control (T_1), organic manure @ 20 t ha^{-1} (T_2), recommended dose of fertilizers (T_3), T_3 + magnesium @ 5 mg kg^{-1} of soil (T_4), T_3 + magnesium @ 10 mg kg^{-1} of soil (T_5), T_3 + magnesium @ 15 mg kg^{-1} of soil (T_6), T_3 + magnesium @ 20 mg kg^{-1} of soil (T_7), T_3 + magnesium @ 30 mg kg^{-1} of soil (T_8), T_3 + magnesium @ 40 mg kg^{-1} of soil (T_9), T_3 + magnesium @ 50 mg kg^{-1} of soil (T_{10}), T_3 + magnesium @ 60 mg kg^{-1}of soil (T_{11}) and T_3 + magnesium @ 80 mg kg^{-1} of soil (T_{12}). The recommended dose of fertilizers (RDF) as per the package of practices of KAU (KAU, 2016) includes the application of 20 t ha^{-1} of organic manure, 250 kg ha^{-1} calcium carbonate and 20:30:10 kg ha^{-1} of N, P_2O_5 and K_2O. The experiment was laid out in completely randomized design (CRD) with four replications in earthen pots of 5 kg capacity and five plants were maintained in each replication.

The quantity of fertilizers were calculated for 5 kg soil. Organic manure in the form of vermi compost was added after one week of application of calcium carbonate (AR grade). Magnesium required for each treatment was supplied through magnesium carbonate (AR grade) two weeks after organic manure application. Three seeds were sown in each pot and one healthy plant retained one week after emergence. Complete dose of phosphorus, potassium and half split of nitrogen was applied after thinning of plant population and second dose of nitrogen was supplied 15 days later. Foliar application of boron (0.05%) was done twice to combat boron deficiency. The nutrients were supplied through water soluble sources. Irrigation with de-ionized water, weed control and plant protection measures were adopted uniformly in each pot.

Plant sample analysis was done for N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B separately from stem, leaf and pods during fifty percentage flowering and at harvest using standard procedures. Biometric parameters such as plant height, number of pods per plant, yield per plant, root nodules per plant were observed at flowering and after harvest. All the data collected were subjected to analysis of variance in CRD using OPSTAT software package [8]. Duncan's multiple range test was employed to test the significance of difference between means of treatments at 5% level of significance.

RESULTS AND DISCUSSION

Effect of treatments on nutrient accumulation in different plant parts of cowpea

Greater variation in content of potassium, calcium and magnesium among various plant parts of cowpea were observed with application of graded doses of magnesium. Whereas accumulation of nitrogen, phosphorus, sulphur, iron, manganese, zinc, copper and boron in stem, leaf and pods of cowpea during flowering and at harvest were not influenced by increasing magnesium concentration in soil.

Table 1 Effect of treatments on uptake of potassium, calcium and magnesium and biometric yield contributing characters of plant

Treatments	Uptake (mg per plant dry weight)			Plant height (cm)	Pods Per plant	Length of pods (cm)	Yield (g plant^{-1})	No of root nodules	
	Potassium	Calcium	Magnesium					At flowering	After harvest
T_1: Absolute control	117.54^{j}	114.13^{i}	26.67^{j}	37.90^{f}	8.25^{f}	9.60^{g}	33.04^{e}	20.5^{g}	5.0^{f}
T_2: Organic manure @ 20 t ha^{-1}	156.59^{i}	176.74^{g}	38.39^{i}	45.70^{e}	10.5^{ef}	11.90^{f}	60.84^{d}	27.0^{efg}	8.5^{ef}
T_3: Recommended dose of fertilizers (RDF)	171.29^{h}	166.71^{h}	42.57^{h}	44.00^{e}	9.00^{de}	12.80^{ef}	63.28^{d}	29.5^{def}	12.5^{cde}
T_4: RDF + magnesium @ 5 mg kg^{-1} of soil	292.11^{a}	213.72^{c}	58.88^{de}	52.80^{c}	19.5^{abc}	17.70^{a}	70.39^{c}	32.0^{cde}	14.5^{bcd}
T_5: RDF + magnesium @10 mg kg^{-1} of soil	267.09^{b}	261.65^{a}	66.62^{a}	61.65^{a}	19.50^{abc}	15.80^{bc}	79.33^{a}	50.0^{a}	20.5^{a}
T_6: RDF + magnesium @ 15 mg kg^{-1} of soil	221.68^{e}	191.64^{e}	55.59^{ef}	56.95^{b}	18.75^{abc}	15.95^{bc}	73.33^{bc}	41.0^{b}	18.5^{ab}
T_7: RDF + magnesium @ 20 mg kg^{-1} of soil	256.42^{c}	255.86^{b}	63.40^{abc}	49.65^{d}	20.25^{ab}	15.05^{cd}	76.57^{ab}	36.5^{bc}	17.0^{ab}
T_8: RDF + magnesium @ 30 mg kg^{-1} of soil	189.45^{g}	182.19^{f}	48.34^{g}	58.95^{b}	17.25^{bc}	17.00^{ab}	75.28^{abc}	26.0^{efg}	17.5^{ab}
T_9: RDF + magnesium @ 40 mg kg^{-1} of soil	219.69^{e}	183.56^{f}	52.45^{f}	48.40^{d}	18.00^{bc}	15.50^{c}	73.30^{bc}	27.5^{ef}	15.5^{bc}
T_{10}: RDF + magnesium @ 50 mg kg^{-1} of soil	223.14^{de}	203.67^{d}	61.25^{cd}	49.80^{d}	21.75^{a}	16.35^{abc}	76.12^{abc}	35.0^{bcd}	17.0^{ab}
T_{11}: RDF + magnesium @ 60 mg kg^{-1} of soil	212.58^{f}	216.88^{c}	64.94^{ab}	48.25^{d}	16.50^{cd}	17.70^{a}	74.64^{abc}	27.5^{ef}	11.0^{de}
T_{12}: RDF + magnesium @ 80 mg kg^{-1} of soil	227.77^{d}	201.53^{d}	62.07^{bcd}	49.55^{d}	18.75^{abc}	13.95^{de}	74.19^{abc}	25.0^{fg}	12.5^{cde}

Graded doses of magnesium supplied were able to produce variation in the accumulation of potassium in various plant parts of cowpea. The highest content of potassium in stem (2.73%) and leaf (2.58%) of plants during flowering were obtained in treatment supplied with organic manure @ 20 t ha^{-1} which indicates a dilution effect due to higher biomass in treatments where fertilizers were applied as per recommendation (T_3 to T_{12}). At harvest, highest stem potassium accumulation was observed in plants received 5 mg kg^{-1} of magnesium and was found on par with that of plants treated with 40 mg kg^{-1} of magnesium. Leaf potassium content ranged between 1.20-1.56% at harvest. The treatments received magnesium @ 5, 15, 50, 60, 80 mg kg^{-1} and absolute control were on par in their leaf potassium accumulation at the time of harvest. About 50 per cent of accumulated potassium can be translocated from shoot to grain in soybean [9].

Similarly, a reduction in potassium content of stem and leaf and a subsequent increase in potassium content of pods were observed at harvest stage. The absence of significant variation in potassium content of wheat forage with increasing levels of magnesium [10]. Whereas, magnesium up to a concentration of 20 ppm had a synergistic effect on concentration of K in all plant parts but had antagonistic effect at higher concentration [11]. The results of this experiment showed a significant variation in potassium content as per graded doses of magnesium with a non-significant antagonistic effect at higher concentration.

Calcium content in stem and leaf of cowpea exhibited high variability at both stages of observation. Whereas calcium content in pods was not found to vary with respect to treatment imposed. Irrespective of magnesium doses, a general decrease in calcium content of stem and an increase in calcium content of leaves were recorded from flowering to harvest stage. Calcium tends to be present at low concentrations in phloem fed tissues and is retained more in leaves [12]. Among the various magnesium doses highest calcium content in stem during flowering was recorded in treatment received 5 mg kg^{-1} of magnesium (1.21%). The leaf calcium content ranged between 2.73-2.16% during flowering. Significantly higher leaf calcium content (2.73%) during flowering was observed in treatment supplied with 5 mg kg^{-1} of magnesium and was found on par with treatment received organic manure alone (2.69%). At harvest, calcium content in stem ranged from 0.73% to 1.27% and between 3.12% and 3.87% in leaves. The calcium content in stem and leaves at harvest were significantly superior in treatment received 10 mg kg^{-1} of magnesium and was on par with that of magnesium at 5 mg kg^{-1} and organic manure alone treated plants.

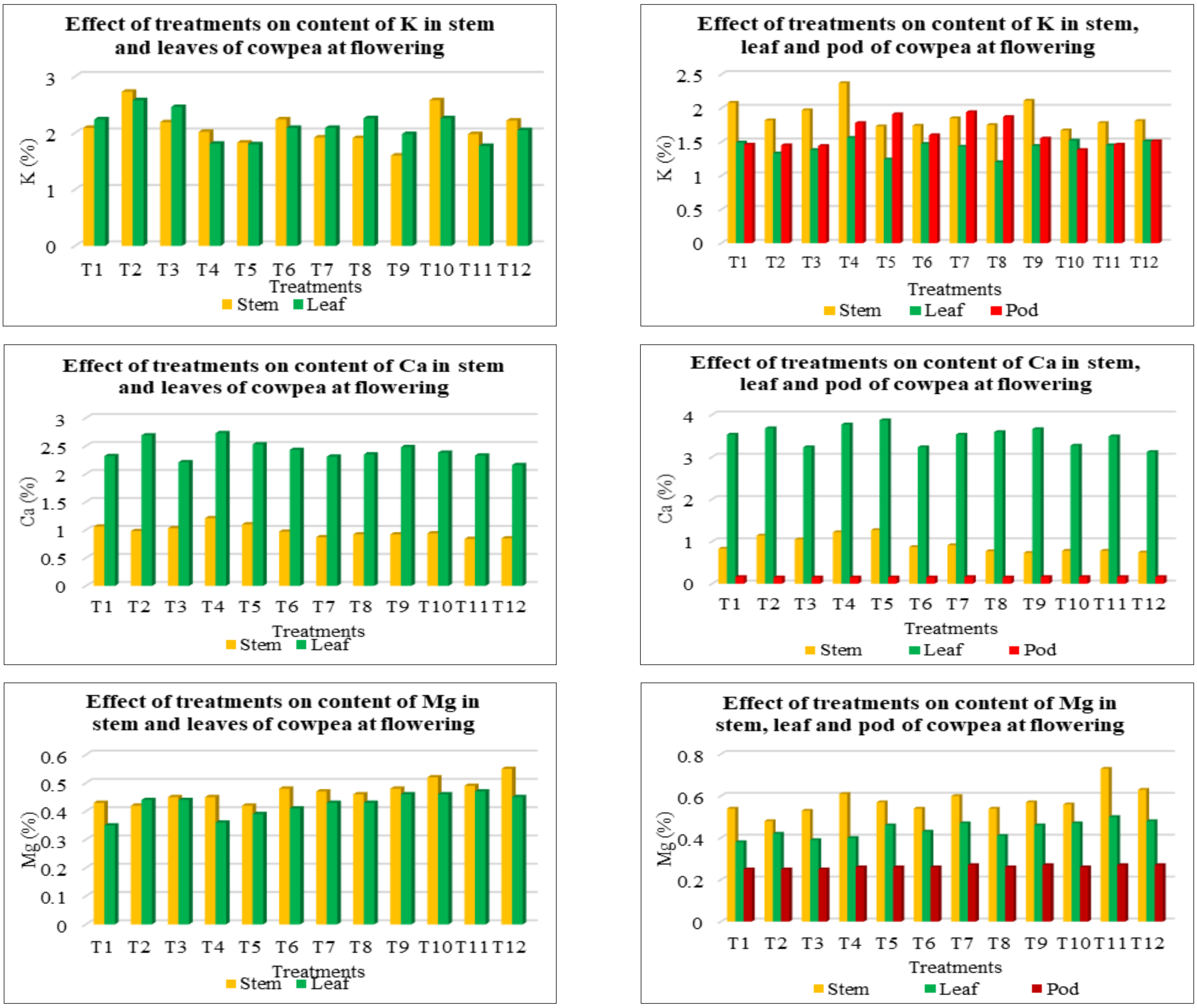

Fig 1 Effect of treatments on potassium, calcium and magnesium content of leaf, stem and pod of cowpea during flowering and at harvest

Increasing levels of magnesium resulted in increasing concentration of magnesium in stem and leaves of cowpea. Similar to calcium, graded doses of magnesium could not record a variation in magnesium content of pods. Magnesium absorbed in excess is stored in the leaves of plants [13]. Analysis of the results obtained for magnesium content in stem of cowpea during flowering showed significantly higher value (0.55%) in treatment at 80 mg kg^{-1} of magnesium and was on par (0.52%) with that of magnesium at 50 mg kg^{-1}. Treatments differed significantly with regard to magnesium content in leaves. The highest value (0.47%) of magnesium in leaves was recorded in plants that received 60 mg kg^{-1} magnesium which was on par with that of magnesium at 50 (0.46%) and 40 mg kg^{-1} (0.46%) while the lowest value was observed in absolute control at flowering. Magnesium supplied at the rate of 60 mg kg^{-1} (0.73%) obtained significantly higher accumulation of magnesium in stem of cowpea at harvest whereas the lowest content (0.48%) was recorded in organic manure alone treated plants (0.48%). Analysis of data on magnesium content of cowpea leaves at harvest showed that significantly higher content (0.50%) was obtained in magnesium treated at 60 mg kg^{-1} and was found on par with that of magnesium @ 80, 50, 40, 20 and 10 mg kg^{-1}. A high positive and significant correlation between rates of magnesium applied and magnesium content in leaves [14]. Relatively good reutilization and redistribution of magnesium through phloem tissues and hence considerable difference in magnesium content of leaves and stem were absent in this experiment [15]. A higher magnesium accumulation in all magnesium applied treatments were recorded towards harvest of the crop compared to flowering which might be due to slow solubility of magnesium carbonate, suggesting to be a better source under acidic soils.

Effect of treatments on uptake of nutrients

The perusal of data on nutrient uptake by crop revealed, plants received 5 mg $kg^{-1}$of magnesium were superior over other treatments to significantly increase the uptake of potassium. The comparison of treatments on uptake of calcium showed that treatment supplied with 10 mg $kg^{-1}$of magnesium to be superior over other treatments. Treatments supplied with 20 and 60 mg $kg^{-1}$of magnesium were on par with respect to magnesium uptake (Table 1). An increased level of magnesium uptake with increasing concentration in soil. But such a trend was absent in this experiment [16].

Effect of treatments on biometric parameters

Significantly higher plant height was obtained in T_5 (supplied with 10 mg kg^{-1} of magnesium) with a mean value of 61.65cm and followed by plants treated with 30 and 15 mg kg^{-1} of magnesium. The treatments differed significantly with respect to number of pods per plant. Significantly higher number of pods per plant was obtained in plants received 50 mg kg^{-1} of magnesium and was on par with that of 5, 10, 15, 20 and 80 mg kg^{-1} of magnesium. A significantly long pods were observed in plants supplied with 5, 30, and 60 mg kg^{-1} of magnesium. The number of nodules was higher during flowering than after harvest. Analysis of the data showed a significant influence of treatments on root nodule formation. Among various treatments significantly higher number of root nodules was recorded in plants treated with 10 mg kg^{-1} of magnesium during flowering stage. The treatments differed significantly with respect to the yield per plant. Plants treated with 10 mg kg^{-1} of magnesium recorded significantly higher yield but was on par with that of 50, 20, 30, 60 and 80 mg kg^{-1} magnesium received plants. The absolute control treatment recorded the lowest yield.

CONCLUSIONS

A pot culture experiment was conducted to study the response of cowpea towards magnesium fertilization in lateritic soils of Kerala during January 2019. The perusal of data on nutrient content in cowpea plant during flowering and harvest, uptake of nutrients, yield and yield contributing characters showed plants received 10 mg kg^{-1} of magnesium to be the optimum dose of magnesium to achieve maximum crop response. A linear response of cowpea towards magnesium doses could not be recorded from the experiment.

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