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

Res. Jr. of Agril. Sci. **12**(1): 143–148

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

Research Paper

Crop Establishment and Weed Incidence in Cowpea under Conservation Tillage and Magnesium Nutrition

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Received: 01 Aug 2020 | Revised accepted: 30 Dec 2020 | Published online: 05 Jan 2021

ABSTRACT

A study on response of cowpea to conservation tillage practices was conducted in Kerala from 2017-2019 with three tillage practices i.e., zero tillage (ZT), minimum tillage (MT), and conventional tillage (CT) with five combinations of potassium and magnesium sulphate; K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (S_1), K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha, K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha, K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha, K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha. Conservation tillage resulted in highest weed dry matter production while weed incidence was less under zero tillage. Weed dry matter production recorded highest in K: $MgSO_4$ @ 40:80 kg/ha. Cowpea germination was poor under ZT and MT compared to normal tillage. Higher grain yield was recorded under minimum tillage along with application of K: $MgSO_4$ @ 40:60 kg/ha.

***Key words*:** Conservation tillage, Cowpea, Magnesium sulphate, Potassium, Weed incidence

Current agricultural practices follow continuous tillage making soil vulnerable to leaching of nutrients and accelerated erosion leading to poor soil health. Hence conservation tillage practices involving zero tillage and minimum tillage is gaining significance world over. One of the major objectives of tillage is weed control and under conservation tillage crop-weed competition may lead to reduction in yield and productivity [1]. Cowpea, known as “vegetable meat” is one of the widely cultivated crops. Leguminous crops have good potential to restore soil fertility and are more adapted to conservation tillage due to deep tap root system [2]. Also, they are less prone to weed competition due to smothering effect and rapid crop growth rate at the initial growth stages. Effectiveness of zero tillage on weed control varies in accordance with weed and crop species as well as with herbicide used, hence appropriate herbicide, timing and dose are critical in weed management in conservation agriculture [3].

Recently, secondary nutrient deficiency symptoms have been reported in cowpea from many areas. The acid soils of Kerala are inherently deficient in calcium, magnesium and sulphur. High rainfall causing leaching of nutrients to deeper layers aggravates this problem [4]. Though liming can meet the crop requirement of calcium, magnesium and sulphur have to be supplied through fertilizers. Liming of acidic soils ameliorates soil acidity and increases Ca uptake [5]. Studies also shows that secondary nutrient requirement of crops is almost similar to phosphorus demand. The availability of Ca and Mg is very low in Kerala soils due to leaching under heavy rainfall and about 80 per cent of soils are deficient in available Ca and Mg [6]. Hence the present study was formulated with the objectives of studying weed competition and crop establishment under conservation tillage, and nutrition on cowpea grain yield.

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MATERIALS AND METHODS

The study was conducted during November- March 2017–2018 and 2018–2019 at College of Horticulture, Thrissur (10° 31’N, of 76° 13’E and 40m above MSL) of the Kerala Agricultural University, India, which has a typical tropical humid climate. The mean maximum and minimum temperature of the experimental area were 34.2°C and 22.5°C respectively. The soil of the experimental field was sandy loam, with an acidic pH of 4.6. Soil nutrient status of the site was, organic carbon (1.1%), available nitrogen (410 kg/ha, high), available P (4 kg/ha, low), available K (107 kg/ha, low) and magnesium (60 mg/kg, deficient).

The experiment was laid out in a rice fallow. The design was RBD and treatment consisted of factorial combination of three tillage practices and five K_2O-$MgSO_4$ doses. Bush type variety of cowpea Anaswara released from KAU was used and seeds were dibbled at spacing of 30 cm × 15 cm. In zero tillage (ZT), herbicide glyphosate was sprayed @ 0.85 kg/ha two weeks before sowing cowpea. In minimum tillage (MT), strip tillage was adopted at a spacing of 30 cm. Proper land preparation was done in conventional tillage plots (CT) where land was ploughed twice followed by formation of small ridges and furrows at a spacing of 30 cm. The crop was raised on ridges at plant to plant spacing of 15 cm.

The K_2O and $MgSO_4$ doses tried were K_2O 10 kg/ha + $MgSO_4$ 80 kg/ha (S_1), K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha (S_2), K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha (S_3), K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha (S_4), K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha (S_5). Potassium was applied as basal dose and $MgSO_4$ was applied two weeks after K application. Lime was applied @ 650 kg/ha as basal dose. A uniform dose of FYM @ 20t/ha and N and P_2O_5 @ 20 kg/ha and 30 kg/ha were applied [7]. Half N was applied as basal and balance as foliar spray at 15 DAS. Hand weeding was done at 30 DAS. Observations on germination percentage was noted at 10 DAS and weed species count and weed dry matter production per sq. m. was taken at 30 DAS and 60 DAS using 0.5 m^2 quadrat. Weeds were first air dried, then oven dried and dry matter production was expressed in g/ square meter. Grain yield per plot was recorded at harvest. Data was analyzed by using OPSTAT statistical software.

RESULTS AND DISCUSSION

Weed species count

Weed spectrum and dry matter accumulation were recorded at 30 and 60 days after sowing. The weed spectrum constituted mainly the broad-leaved weeds which included, *Melochia corchorifolia*, *Commelina diffusa*, *Aeshynomene indica*, *Ludwigia parviflora*, *Cynotis axillaris*, *Elephantopus scaba*, *Mollugo pentaphylla*, *Mollugo dystica*, *Emilia sonchifolia*, *Scoparia dulcis*, *Cleome burmanii*, *Ageratum conyzoiides*, *Scoparia dulcis*, *Digitaria sanguinalis*, *Alternanthera sessilis*, *Phyllanthus niruri*, *Cyanotis axillaris* etc. Results on species diversity indicated that, *Melochia corchorifolia* was the major dicot weed species observed (Table 1). Total number of *Melochia corchorifolia* recorded was highest under conventional tillage (32/m^2) which was four times higher than that recorded under zero tillage (8/m^2).

Table 1 Weed species count (Number/square meter) under various tillage systems

	Melochia corchorifolia	*Aeshynomene indica*	*Brachiaria mutica*	*Cynotis axillaris*	*Commelina diffusa*	*Ludwigia parviflora*	*Elephantopus scaba*	*Mullugo dystica*	*Mullugo pentaphylla*	*Scoparia dulcis*	*Isachne miliacea*	*Echinochloa colona*
						30 DAS						
ZT	8	2	2	1	-	-	-	-	-	1	-	1
MT	14	1	2	1	-	-	1	1	1	-	3	-
CT	32	2	1	1	1	1	-	-	-	-	-	-
						60 DAS						
ZT	2	1	1	-	-	-	-	-	-	1	-	1
MT	2	1	2	1	-	-	1	1	1	-	3	-
CT	10	1	-	1	1	1	-	-	-	-	-	-

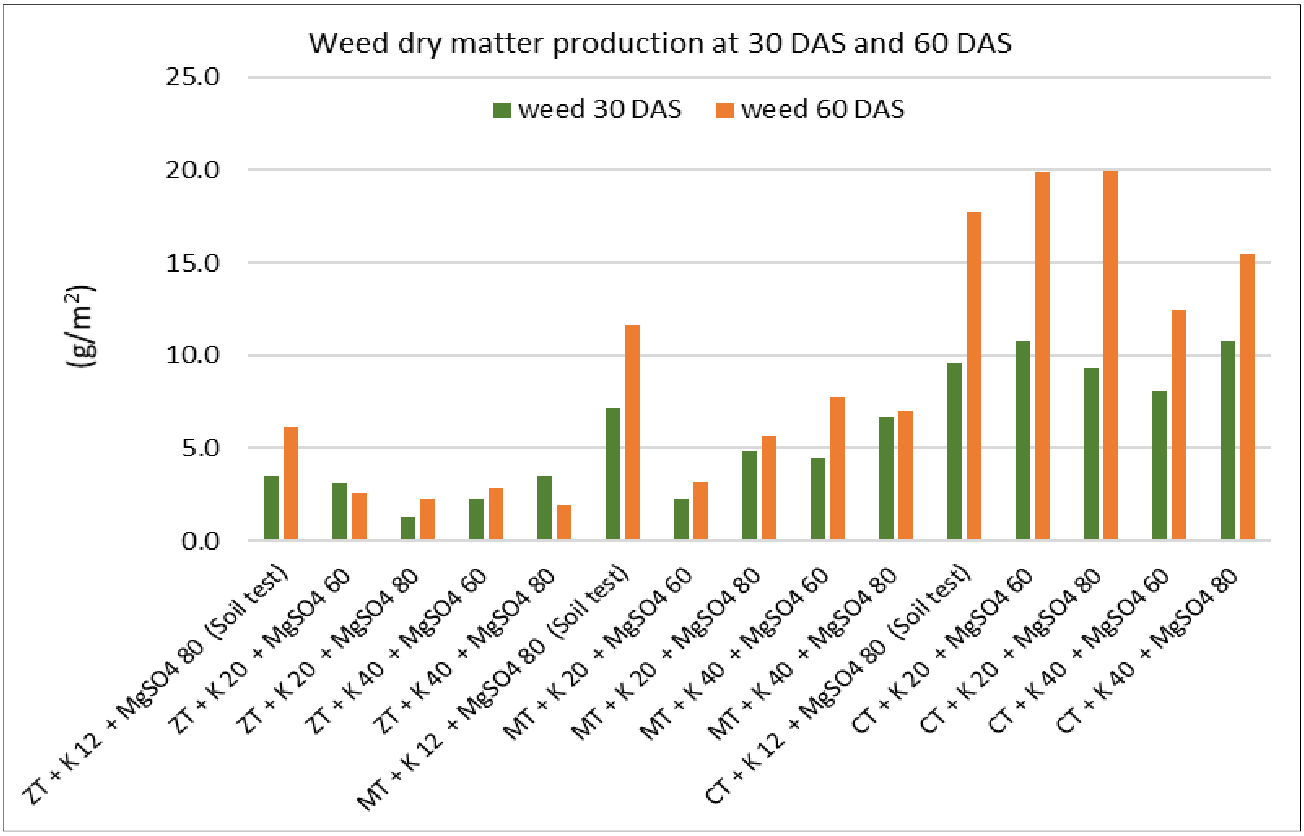

Fig 1 Weed dry matter production at 30 days after sowing and 60 days after sowing

Brachiaria mutica, *Isachne miliacea* and *Echinochloa colona*, were the grass species observed. The only sedge observed in the field was *Cyperus iria*, however population was very low. Species diversity and weed density were more under conventional tillage during both years. Grasses like *Brachiaria mutica*, was low in number under conventional tillage but was noticed higher under minimum tillage. Similarly, number of *Isachne miliacea* was higher under minimum tillage as compared to zero and conventional tillage. This was due to the fact that these weeds persisted in the field as entire area was not ploughed. *Isachne miliaceae* is a problem weed in rice propagated through seeds as well as vegetative propagates. As the field was under rice in the previous season, this weed persisted.

Zero tillage resulted in comparatively lower number of weeds and diversity. This was due to complete drying of all weeds due to glyphosate application. Also, as there was no soil disturbance weed seeds in lower layers failed to germinate. The higher number of weeds in conventional tillage clearly indicate that ideal condition of germination of *Melochia* seeds (Chocolate weed) was there due to soil disturbance and loosening of surface layers. Fewer weed emergence under zero-tillage is reported by many workers. In zero tillage, no soil disturbance resulted in less as well as late emergence of weed seeds and hence weed competition to succeeding crop was less [8]. In rice, conventional tillage with 100 per cent residue incorporation registered higher total weed density and biomass over no-tillage [9].

Tillage affects emergence pattern of various weed species and they found that seedling emergence of *Digitaria ciliaris, Echinochloa colona, Eleusine indica, Ageratum conyzoides, Eclipta prostrata,* and *Portulaca oleracea* were greater in zero tillage compared to conventional and minimum tillage [10]. The population of weeds like *Echinochloa colona* and *Digiteria arvensis* was observed to be lowest in zero tillage-raised bed types over a four-year study [11].

Weed dry matter production

A similar trend to that of weed count could be observed in weed dry matter production also. Conventional tillage resulted in highest weed dry matter at 30 DAS and 60 DAS (9.7 g/m^2 and 17.1 g/m^2 respectively) followed by minimum tillage (Fig 1). The lowest weed dry matter was noted under zero tillage system (2.7 g/m^2 and 3.2 g/m^2 respectively). This was due to the lower weed population resulted from application of broad-spectrum herbicide together with failure of weed seeds to germinate from deeper layers due to unfavorable tilth. Effectiveness of zero tillage on weed control varies in accordance with weed and crop [12]. In conservation tillage, minimal soil disturbance may facilitate most of the weed seeds to remain on the soil surface even after sowing of the crop which are more vulnerable to surface-dwelling granivores, like birds and insects. Reports shows that, especially in no-tilled conditions, newly dispersed weed seeds remain on the soil surface itself [13].

Application of K: $MgSO_4$ @ 40:80 kg/ha (S_5) and K: $MgSO_4$ @ 12:80 kg/ha (S_1) registered higher weed dry matter at 30 DAS. At 60 DAS, application of K: $MgSO_4$ @ 10:80 kg/ha (S_1) resulted in highest weed dry matter (11.7 g/m^2). Studies indicated that fertilizers benefit weeds more than crops and the application of fertilizers increased weed density and their biomass [14]. Results also indicated that various doses of nutrients under different tillage systems produced comparable weed dry matter at initial growth stage of crop. However, by 60 DAS, K: $MgSO_4$ @ 20:60 and 20:80 kg/ha at conventionally tilled plots produced higher weed dry matter. This might be due to more availability of nutrients along with loose soil together with more weed density under conventional tillage. Tillage practices significantly affected weed density while, K sources and levels had no significant influence on weed density per m^2 and weed dry weight [15].

Sowing of cover crops on zero tilled plots helps in decreasing population of annual weed species because germination of weed seeds from existing seed bank is not induced under no-tillage as observed under conventional tillage [16]. Maize-wheat-soybean/common vetch under tilled and untilled conditions either with or without stubble retention, and observed that, number of weed species and weed density in all three crops been affected by crop growth stage and tillage [17].

Table 2 Tillage and nutrients interaction on germination percentage (%) of cowpea

Treatments	2017	2018	Pooled
Tillage			
Zero tillage (ZT)	44.7^c	43.2^c	44.0^c
Minimum tillage (MT)	55.8^b	60.8^b	58.3^b
Conventional tillage (CT)	78.7^a	79.7^a	79.2^a
C.D (0.05)	2.67	3.3	3.0
Nutrients			
S1- K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (Soil test)	59.8	62.5	61.2
S2- K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha	57.5	58.9	58.2
S3- K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha	59.7	64.9	62.3
S4- K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha	60.9	61.7	61.3
S5- K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha	60.9	58.2	59.5
C.D (0.05)	NS	NS	NS
Interaction			
ZT + K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (Soil test)	46.7	51.4	49.0
ZT + K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha	44.7	41.4	43.0
ZT + K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha	52.4	49.4	50.9
ZT + K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha	44.2	38.5	41.4
ZT + K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha	35.7	35.4	35.5
MT + K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (Soil test)	48.9	54.3	51.6
MT + K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha	43.1	58.2	50.7
MT + K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha	63.8	60.8	62.3
MT + K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha	55.3	68.2	61.8
MT + K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha	68.1	62.4	65.2
CT + K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (Soil test)	84.0	81.7	82.8
CT + K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha	84.7	77.0	80.9
CT + K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha	63.0	84.3	73.7
CT + K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha	83.1	78.4	80.7
CT + K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha	78.8	76.9	77.9
C.D (0.05)	NS	NS	NS

Germination

Tillage had significant influence on germination percentage of cowpea all tillage practices differed significantly from each other (Table 2). Germination percentage was highest under conventional tillage system (79%) during both years while only 58 per cent germination was observed under minimum tillage and 44 per cent under zero tillage system. Germination percentage directly influences crop density, which in turn affects crop growth which finally influences yield. Higher soil compaction resulting in higher soil resistance to germination which is a characteristic feature of zero tillage might be the reason for lower germination rate under zero tillage. In these plots, seeds were dibbled manually at the required spacing and there was no loosening of soil creating hard tilth lead for poor germination.

Conventional tillage resulted in good aeration, and low bulk density, which ultimately favoured seed germination and highest rate of germination. The low bulk density (1.2 g/cc) in conventional tillage compared to high BD of 1.5 g/cc in zero tillage plots indicated soil compaction and poor aeration which is not ideal for germination. This might have also led to unfavourable moisture condition for germination of seeds. The soil compaction and low soil moisture under no tillage system, germination and crop growth of green gram was reduced [18]. Poor placement of seeds in ZT plots lead to poor seedling emergence as under ZT system, seeds will be exposed or will be placed under crop residue [19]. In dry bean, seedling emergence was delayed under ZT as compared to conventional tillage [20]. In green gram conventional tillage resulted in higher rate of germination [21]. It was found that application of variable doses of K and $MgSO_4$ doses and the interaction between nutrients and tillage had no influence on germination percentage. Potassium, had no significant effect on germination percentage of green gram raised under various levels of tillage [22].

Grain yield

Yield is a result of total uptake of nutrients, total photosynthates produced during crop growth and as well as the portion of photosynthates partitioned towards the economic part. Among the tillage systems, minimum tillage resulted in the highest grain yield of cowpea (Table 3). Both conventional tillage and zero tillage gave lower and statistically comparable yields. The results indicate suitability of minimum tillage for rice fallow cowpea production. Compared to double digging, furrow tillage, and conventional tillage, highest plant biomass production at reproductive stage, grain yield and number of pods of chickpea was noticed in strip tillage, as the strips helps in conserving soil moisture reducing evaporative loses making it available for consumptive use by this deep-rooted crop [23].

Table 3 Interaction effect of tillage and variable doses of potassium and magnesium sulphate on grain yield of cowpea

Treatments	Grain yield per plot (kg /25 m^2)		
	2017	2018	Pooled
Tillage			
Zero tillage (ZT)	1.4^b	1.8^b	1.6^b
Minimum tillage (MT)	2.0^a	1.7^b	1.9^a
Conventional tillage (CT)	1.2^c	2.0^a	1.6^b
C.D (0.05)	0.1	0.1	0.1
Nutrients			
S1- K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (Soil test)	1.6^b	1.6^c	1.6^b
S2- K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha	1.4^c	1.6^c	1.5^c
S3- K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha	1.4^c	1.8^{bc}	1.6^b
S4- K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha	1.9^a	2.2^a	2.0^a
S5- K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha	1.5^{bc}	1.9^b	1.7^b
C.D (0.05)	0.2	0.1	0.1
Interaction			
ZT + K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (Soil test)	1.2^{cd}	2.0^{cd}	1.6^{defg}
ZT + K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha	1.1^{cd}	1.3^g	1.2^i
ZT + K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha	1.1^d	1.8^{def}	1.4^h
ZT + K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha	1.7^b	2.0^{bcd}	1.8^{cd}
ZT + K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha	1.8^b	1.7^{ef}	1.7^{cdef}
MT + K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (Soil test)	2.6^a	1.6^f	2.1^b
MT + K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha	1.8^b	1.7^{ef}	1.7^{cdef}
MT + K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha	2.0^b	1.3^g	1.6^{defg}
MT + K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha	2.5^a	2.1^{bc}	2.3^a
MT + K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha	1.2^{cd}	1.8^{cde}	1.5^{gh}
CT + K_2O 12 kg/ha + $MgSO_4$ 80 kg/ha (Soil test)	1.1^d	1.3^g	1.2^i
CT + K_2O 20 kg/ha + $MgSO_4$ 60 kg/ha	1.3^{cd}	1.9^{cde}	1.6^{defg}
CT + K_2O 20 kg/ha + $MgSO_4$ 80 kg/ha	1.1^d	2.2^b	1.6^{defg}
CT + K_2O 40 kg/ha + $MgSO_4$ 60 kg/ha	1.4^c	2.5^a	1.9^{bc}
CT + K_2O 40 kg/ha + $MgSO_4$ 80 kg/ha	1.4^c	2.2^b	1.8^{cd}
C.D (0.05)	0.3	0.3	0.2

Tillage and nutrient interactions had significant effect on grain yield. Minimum tillage with application of K: $MgSO_4$ @ 40:60 kg/ha resulted in highest grain yield (2.3 kg/25.2 m^2). Treatments which yielded higher number of pods per square meter, resulted in higher grain yield of cowpea. This can be attributed to the improved crop growth under minimum tillage. Water loss from the top soil was reduced under minimum tillage and the yield of succeeding winter crops were increased [24]. Ploughing the strips alone before sowing of cowpea helps in decreasing evaporation and conserving soil moisture, which might have allowed maximum absorption of water, also the undisturbed area near the strips might have reduced weed density, and hence decreased weed competition. These factors ultimately caused increase in crop yields.

When plant population was higher, number of pods per plant, number of seeds per pod and hence seed yield per plant was reduced [25]. Seed yield and number of pods per plant of chickpea under reduced tillage was higher than no-tillage and conventional tillage [26]. Application of K @ 40 kg/ha with $MgSO_4$ @ 60 kg/ha might have increased the rate of photosynthesis leading to higher yields. Potassium is fundamental for activating enzymes essential for many metabolic processes, and also for water management in plants [27]. Effect of various levels of potassium on yield of chickpea varied significantly and the higher yield was noted with 60 kg K_2O/ha and the increase was due to higher number of pods per plants, seeds per plant and 100-grain weight [28].

K deficiency reduced photosynthetic rate and the rate of ATP production [29]. This finding is one of the reasons why K has a positive effect on yield. K fertilization in the form of potassium sulphate increased the number of pods in faba bean [30]. When compared to control plots, foliar application of K or Mg resulted in higher yields and number of pods in mungbean [31]. Similarly, application of $MgSO_4$ @ 60 kg/ha which can increase chlorophyll content and leaf area also might be another reason for higher yields of cowpea. In plant system, magnesium is phloem mobile and readily translocated to actively growing sink [32]. Magnesium is vital in chlorophyll formation and increasing photosynthetic rate. Mg plays vital role in physiological processes and its key function is phloem loading, a co-factor and allosteric modulator for more than 300 enzymes including Calvin cycle, kinases, RNA polymerases and ATPases [33]. Mg is crucial for the transport of assimilates from source to sink, hence Mg deficiency stress in plants disturbs photosynthates partitioning between roots and shoots, leading to accumulate assimilates in leaves, reducing the development of sink [34]. Increase in crop yield was observed in faba bean (*Vicia faba*) [35] with foliar application of Magnesium.

CONCLUSIONS

From the results obtained it can be concluded that, practicing herbicide based zero tillage reduces the incidence of weeds, whereas conventional tillage higher weed incidence and competition due to germination of weed seeds from soil seed bank. Application of higher levels of nutrients also increases weed density as well as species diversity. Cowpea having a deep tap root system yields higher under conservation tillage practices and the crop responses well to the application of potassium and magnesium sulphate fertilization. Adoption of minimum tillage along with application of potassium and magnesium sulphate @ 40:60 kg/ha can be followed in rice fallow cowpea production for higher grain yield of cowpea in soils deficient in potassium and magnesium.

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