PERFORMANCE OF GREENGRAM (*Vigna radiata* (L.) WILCZEK) CULTIVARS UNDER DIFFERENT TILLAGE METHODS

By
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(2016-11-048)

THESIS

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DECLARATION

I, Abid V. (2016-11-048) hereby declare that the thesis entitled **"Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods"** is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me any degree, diploma, fellowship or other similar title, of any other university or society.

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Certified that this thesis entitled **"Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods"** is a record of research work done independently by **Mr. Abid V.**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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LIST OF ABBREVIATIONS

^{o}C	Degree Celsius
CD	Critical Difference
cm	Centimetre
COH	College of Horticulture
DAS	Days after sowing
E	East
et al	And others
fb	Followed by
g	Gram
ha	Hectare
KAU	Kerala Agricultural University
kg	Kilogram
m	Metre
N	North
No.	Number
RH	Relative humidity
SEm	Standard Error of mean
sp	Species
t ha^{-1}	Tonnes per hectare

INTRODUCTION

1. INTRODUCTION

Pulses have great potential to improve human health, conserve soils, protect the environment and contribute to global food security as well as nutritional security. The world acreage under pulses was 851.91 lakh ha with a production of 774.73 lakh tones (DPD, 2017). India ranked first in area and production with 35 and 25 percentages, respectively of world acreage and production. But the productivity (660 kg ha^{-1}) of pulses in India is far below the world average (909 kg ha^{-1}) (DPD, 2017).

In India, pulses are cultivated on marginal lands under rainfed conditions. Low yield of pulses in India compared to other countries is attributed to the poor spread of improved cultivars, non-adoption of technologies and abrupt climatic changes (NCAER, 2014). Greengram [*Vigna radiata* (L.) Wilczek] is one of the thirteen food legumes grown in India and the third most important pulse crop after chickpea and pigeonpea. The total area under greengram in India was 34.50 lakh ha with a total production of 15.91 lakh tones (DPD, 2017). The area and production was the highest in Rajasthan (32.76% and 30.61%) followed by Maharashtra (11.95 % and 10.58%). The productivity was the highest in Punjab (845 kg ha^{-1}) followed by Jharkhand (704 kg ha^{-1}) and Andhra Pradesh (696 kg ha^{-1}) (DPD, 2017).

Greengram or mungbean is one of the hardiest among pulse crops (Shersingh *et al*., 2016). Greengram is a protein rich staple food. Because of its better nutritional quality, it is called as "Queen of pulses". It contains about 25 per cent protein, which is almost three times that of cereals. Greengram seeds are also rich in fibre, antioxidants and phytonutrients.

Large areas are left as fallow during summer season after the harvest of rice crop in India. Conservation agricultural practices for utilizing the residual soil moisture can be done by growing pulse crop after rice crop in the rice fallow areas. Better performances of pulse crops in these rice fallows require proper understanding of the system ecology and constraints. By the use of conservation agricultural practices like minimum tillage and residue mulching, pulse crops like blackgram or greengram can be better established. Diversifying cropping systems with greengram can serve as an effective alternative to summer fallowing in Kerala. With introduction of improved short duration cultivars significant expansion in area and production has been observed in summer mungbean during last one decade (Chadha, 2010). Moreover, being a short duration crop, it has great scope in rice based cropping systems of Kerala.

Pulses, endowed with unique ability of biological nitrogen fixation, deep root system, low water requirements and capacity to withstand drought, constitute an important component of crop diversification and resource conservation technology (Kumar *et al.*, 2012). Inclusion of a short duration catch crop in summer like mungbean not only provides additional yield but also economizes nitrogen in the subsequent crops. One of the major constraints in spread of greengram is non-availability of high yielding cultivars. Today, a large number of improved varieties of greengram have been released for improved yield, disease and pest resistance, short duration, synchronous maturity and short stature suitable to varied agro-climatic and soil conditions. Adoption and popularization of short duration, pest resistant high yielding cultivars with added ability to adjust in the intensive cropping system is need of the hour (Pooniya *et al.,* 2015).

Presently, minimum tillage and chemical tillage practices are gaining importance due to their role in soil and moisture conservation. A change to conservation tillage along with improved genotypes will be beneficial to farmers due to reduced costs and improved yield. Behera *et al.* (2014) reported that a pulse crop like greengram can be successfully grown with conservation agriculture practices with maximum yield and profit in rice fallows, thus enhancing the system productivity and profitability. Pulses can boost total productivity of the rice fallows by increasing the availability of nutrients, changing pest cycles, enhancing the nutrient and water use efficiency and augmenting system diversity (FAO, 2016).

Among various production practices, establishment techniques, weed management practices and new cultivars have vast potential to enhance yield of greengram. Not much research works has been done in these aspects in Kerala. Hence, the present investigation was carried out for standardizing the production technologies for enhancing the productivity of greengram with the following objectives:

- To study the response of selected greengram cultivars under different tillage methods
- To identify the most economical combination of greengram cultivar and tillage.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

An experiment entitled "Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods" was undertaken with the objectives to study the response of selected greengram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage. Studies on greengram cultivars and effect of tillage methods on crop growth and yield were reviewed and presented in this chapter.

Pulses with low input requirements, short duration, easy establishment and soil fertility restoration property are ideal for rice fallows (Behera *et al*., 2014). Conservation agriculture with pulses provides a basis for sustainable agricultural intensification, including integrated crop approaches. Greengram is the third important pulse crop cultivated throughout India (Gohil *et al*., 2017).

2.1 EFFECT OF TILLAGE METHODS ON GROWTH, YIELD AND QUALITY ATTRIBUTES OF GREENGRAM

Crop performance is determined by growth, development and yield. All these processes are dynamic and influenced by environmental factors. Those environmental factors includes aerial conditions and soil conditions. Aerial conditions such as precipitation and radiation together with soil conditions such as soil moisture and availability of nutrients influence crop development, growth and yield.

Tillage is the manipulation of soil for obtaining optimum conditions for germination, establishment and growth of crops (Das *et al.* 2014). Tillage affects crop performance by modifying the soil environment. Soil physical, chemical and biological properties are affected by tillage, including soil moisture content and water movement, soil structure, porosity, soil nutrient status and microbial population.

Conservation agriculture practices may help to establish the pulse crops like greengram, black gram, lentil, pea, etc. with the help of zero tillage and residue mulching. Zero tillage helps in conserving residual moisture and timely sowing of crops after rice harvest and residue mulch helps in maintaining and conserving the soil moisture for longer period, thus increasing crop productivity. Kar and Kumar (2009) observed better performance of greengram, blackgram, lathyrus and pea in the rice fallows of north east India using residual soil moisture. Onyari *et al*. (2010) found that tillage methods influenced crop growth, biomass, yield components and grain yield in Kabuli chickpea, var. ICCV 95423 under semi-arid conditions in Kenya.

Conservation agriculture is a concept for resource-efficient agricultural crop production based on an integrated management of soil, water and biological resources combined with external inputs (FAO, 2008). Recently resource conservation technologies, involving minimum tillage practices advanced significantly (Siddique *et al.,* 2012). The pillars of conservation agriculture are reduced tillage with crop residue management and crop rotation. Conservation tillage includes minimum and zero tillage which was introduced as an alternative to traditional (conventional) tillage to check soil degradation and to promote sustainable agricultural system. Due to conservation tillage practices, pulse production in summer fallows increased. These changes also contributed to the reduction in land degradation and reduced greenhouse gas (GHG) emission (Awada *et al*., 2014). The minimum tillage and no-tillage systems provided the best alternatives to conventional tillage, due to their conservation effects on soil and crop yield increase. Correct choice of tillage system for the crops in a rotation helped to reduce energy consumption (Rusu, 2014).

Higher growth rate and grain yield of blackgram was noticed under ploughed soil (Mahata *et al*., 1992). Guzha (2004) reported lower yield from untilled plots of sorghum than tilled plots due to lower water retention in the untilled plot.

Moisture conserving properties (surface residues) of no till plots resulted in higher yield than reduced tillage management (Varsa *et al.,* 1997). Khan *et al.* (2009) observed significantly higher value of plant height, test weight, grain yield, biological yield and LAI of maize with minimum tillage and conventional tillage compared to deep tillage. Arif *et al.* (2007) reported higher grain yield recorded in conventional tillage as compared to reduced tillage.

Compared to minimum tillage higher plant height, grain numbers and 1000 grain weight were observed with conventional tillage whereas higher total dry matter and grain yield were recorded with deep tillage (Khurshid *et al*., 2006). Díaz-Zorita *et al*. (2004) reported higher yield of maize under no till plot due to maintenance of large number of mesopores and greater hydraulic conductivity.

Singh *et al*. (2006) observed higher plant height, cobs per plant and grain yield of maize with conventional tillage than zero tillage and minimum tillage. Sarkar and Singh, (2007) reported higher grain yield of barley was due to reduction in ploughing from 150 to 90 mm. Zero tillage recorded the least cassava tuber yield compared to ridge tillage and mound tillage (Peter, 2008).

Verma and Bhagat (1992) observed that no-tillage seeding method was more profitable and remunerative as it gave higher grain yield (12.9%), straw yield (18.5%), net return (29.2%) and cost benefit ratio (2.1%) than conventional tilled wheat. Dhiman *et al*. (2000) reported more number of effective tillers per m^2 and grains per year in addition to grain yield of wheat under zero tillage than conventional tillage. Kumar and Yadav (2005) observed that significantly lesser days were taken to attain spike initiation, anthesis and physiological maturity of wheat under conventional tillage than

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zero tillage. Higher growth and yield attributes in durum wheat under no-tillage operations compared to conventional tillage was due to lower water evaporation combined with higher soil water availability (De Vita *et al*., 2007). According to Singh (2015), tillage practices did not influence days to 50 per cent flowering and days to maturity. As moisture availability was higher in minimum tillage, days to 50 per cent flowering and days to maturity were delayed in minimum tillage. Banjara (2017) studied the effect of different tillage practices on growth, yield and economics of chickpea (*Cicer arietinum L.*) under rainfed condition of Chhattisgarh. The results revealed that significantly higher plant height, branches, dry biomass, pods per plant, seed and stover yield and economics were obtained under minimum tillage system.

Jan *et al*. (2012) reported maximum grain yield of greengram (663 kg ha^{-1}) under conventional method of tillage and minimum yield (527 kg ha^{-1}) under reduced tillage system. Huggi and Kalaghatagi (2016) opined that tillage practices didn't differ significantly with respect to growth parameters of different summer crops at all growth stages. They also found that there was a significant difference among tillage practices with respect to grain yield. Significantly higher grain yield was recorded in zero tillage which was followed by minimum tillage.

Shafaqat *et al.* (2016) found that zero tillage influences the yield and yield attributes by influencing the soil-plant-water relations and modifies root growth and distribution in the soil profile.

The highest grain yield of lathyrus, pea, blackgram and greengram was obtained for reduced tillage compared to other tillage practices (Kar and Kumar, 2009). Meena *et al*. (2015) found that higher dry weight and volume of greengram roots under zero tillage was due to soil compaction in the 0-15 cm layer of soil.

2.2 EFFECT OF TILLAGE METHODS AND CULTIVARS ON WEEDS

Weeds are the major deterrent to the development of sustainable crop production. Farmers follow several practices for managing weeds in different cropping systems, of which at present the use of herbicides are common due to the scarcity of labourers. The sustainability of these systems is being questioned because of environmental, social and economic concerns caused by global competition, production cost, soil erosion, environmental pollution and concern over the quality of rural life. Enhancing the crop competitiveness through preventive methods, cultural practices, mechanical methods, plant breeding, biotechnology, biological control and crop diversification will be the central in new paradigms of weed management. Integration of above techniques will be key to sustainable weed management that maintain or enhance the crop productivity, profitability and environmental quality.

The reason behind the change in weed population dynamics is the shift from the tillage system from extensive soil disturbance to minimum tillage (Buhler, 1995). Crop rotation, tillage systems, application of agrochemicals and other agricultural practices affect the soil weed seed bank and weed flora (Marshall *et al*., 2003).

Nanjappa (2013) reported that tillage and soil depth had significant effects on weed dynamics and weed seed bank. Weed seed bank size was greater in minimum tillage than conventional tillage or reduced tillage. Parwada *et al*., (2014) observed that tillage practice had significant effect on weed density. Conventional tillage + mulch and basin planting + mulch was more effective in controlling weeds.

Buhler (1992) observed the higher density of green foxtail and common lambsquarter under chisel plough and no tillage compared to other tillage systems. Thomas *et al*. (2004) reported weeds associated with reduced tillage and zero tillage were perennial weeds like Canada thistle and perennial sowthistle whereas annual weeds were associated with a range of tillage systems. Highest species diversity was promoted by no tillage compared to chisel plough and mould board plough tillage (Murphy *et al*., 2006).

Malik *et al*. (1993) observed no reduction in weed density due to selection of cultivars. Priya *et al.* (2015) noticed density and dry weight of weeds associated with crops was significantly influenced by crop cultivars.

2.2.1 Weed Management in Greengram Cultivation

Punia *et al*. (2013) studied the floristic composition of weeds in greengram and blackgram. Weed flora in greengram was more diverse as compared to blackgram. Twenty-two weed species (5 grassy, 3 sedges and 14 broad-leaved) belonging to12 families were found dominant in greengram, where as in blackgram only 11 weeds of 7 families were found to be very aggressive. Broad-leaved weed *Digera arvensis* (L.) of family Amarthanceae was the most dominant and aggressive weed of both crops with a relative density and frequency of 51.1 per cent and 86 per cent in green gram whereas in blackgram it was 38% and 96%, respectively.

The loss of yield due to weeds in summer greengram ranged from 40-68 per cent and the potential yield is generally not realized (Tamang *et al*., 2015). They also found that chemical tillage with the available pre and post emergence herbicides were able to check the emergence and growth of annual grasses, broadleaved weeds and sedges in greengram and maximizing seed yield of greengram.

Ali *et al*. (2013) reported that application of imazethapyr @100 g a.i ha^{-1} at 15-20 DAS in *kharif* greengram was found to be most effective in reducing weed population, the highest per cent mortality of weeds, less dry weight and higher weed control efficiency and the lowest weed index. The application also resulted in higher growth attributes and seed yield. Choudhary (2013) reported that pre-emergence application of pendimethalin 1.0 kg a.i. ha^{-1} in blackgram, pigeonpea, kidneybean, cowpea, chickpea and lentil resulted in higher grain yield.

Kumar *et al.* (2014) reported the efficacy of post emergence herbicide Imazethapyr in summer mungbean and results revealed that weeds reduced the yield up to 38.6 per cent. Post-emergence application of imazethapyr significantly increased weed control efficiency up to the dose of @ 80 g ha^{-1}. The increased yield under imazethapyr was mainly due to the increase in growth and yield attributes. The relative suppression effect of imazethapyr was more for grassy weeds when compared to sedges and broad leaved weeds. Post-emergence application of imazethapyr significantly increased weed control efficiency up to the dose of @ 80 g ha^{-1}.

Singh *et al.* (2016) studied the growth and yield parameters of greengram and reported that application of pendimethalin at 1.0 kg ha^{-1} recorded more number of pods per plant, seeds per pod, higher test weight, seed yield, stover yield and harvest index.

2.3 INFLUENCE OF CULTIVARS ON GROWTH, YIELD AND QUALITY ATTRIBUTES OF GREENGRAM

Potential yield of greengram cultivars are low. The limited gene pool of *Vigna* has restricted the conventional breeding programme to improve the yield of green gram. Genetic enrichment from their wild relatives constitutes an important approach to widen the base of genetic variability (Borah *et al.*, 2017).

Today, a large number of improved varieties have been released for improved yield, disease and pest resistance, short duration, synchronous maturity and short stature suitable to varied agro-climatic conditions. Adoption and popularization of short duration, pest resistant high yielding cultivars with added ability to adjust in the intensive cropping system is need of the hour (Pooniya *et al.,* 2015).

Ansari *et al.* (2000) opined that low yield of greengram cultivars on farmers field were due to cultivation of traditional low potential cultivars and improper agronomic practices. In greengram, the yield gap may be attributed to improper agro-technology being used by the farmers, which can be abridged by adopting advanced production technology (Malik *et al.*, 2006).

The critical leaf area index of greengram is 3 to 4 which can enable the crop to intercept over 90 per cent of the incident radiation during pod filling stage (Muchow, 1985). Siddique *et al.* (2006) reported that mungbean varieties differed significantly with respect to yield contributing characters and seed yield. Rasul *et al.* (2012) reported that the varieties of greengram differed significantly in number of nodules per plant varied due to genetic variability and other environmental factors under cultivation.

Singh *et al.* (1985) studied the response of greengram varieties *viz.*, PS-16, LGG-l27, PBM and PIMS-3 in summer and *kharif* seasons. The results revealed that number of pods per plant, number of seeds per pod, 100 seed weight and harvest index were more in PBM and PIMS-3 over PS-16 and LGG-127. All the varieties grown during summer recorded higher yield as compared to *kharif* season.

Madhu (2013) evaluated three varieties of mungbean (DGGV-2, IPM-02-14 and SEL-4) on *Vertisols* transition tract Zone VIII of Karnataka during *kharif*-2012. Genotype DGGV-2 recorded significantly higher seed yield (1113 kg ha^{-1}) compared to IPM-02-14 (1082 kg ha^{-1}) and SEL-4 (1021 kg ha^{-1}). Dash and Rautaray (2017) reported that the gross expenditure in HYV was higher than Farmer's variety (Local check).The HYV Pusa Vishal recorded the highest gross return and net profit of Rs.58136 ha^{-1} and Rs.37286 ha^{-1}, respectively. The same variety had also maximum incremental B:C ratio (2.80) due to higher productivity which was followed by IPM-02-14, SML-668 and TARM-1, respectively.

Bhowaland and Bhowmik (2014) reported that variety and date of harvest had significant influence on various crop characters and seed yield. The variety Bina Mung 7 showed superiority in plant height, number of branches, number of effective nodules, total number of pods and number of seeds per pod over other two varieties resulting in the highest seed yield of 1856 kg ha^{-1}.

Patel *et al.*(2016) studied the yield and economics of greengram cultivars viz., Meha and GM 4 and the results revealed that green gram cultivar Meha performed better by recording17.3 and 15.3 per cent higher seed yield and Stover yield, respectively over GM 4. Maximum net return was recorded from the cultivar Meha.

Ahmad *et al.* (2004) reported that management practices and plant densities greatly affect crop growth and grain yield of greengram. This was a key factor in the flexibility and yielding ability of cultivars. The cultivars, Phule mung-2 and Vaibhav recorded higher growth parameters and yield compared to Kopergaon and AKM-8802 (Gorade *et al.*, 2015).

2.4 INTERACTION EFFECTS OF TILLAGE METHODS AND CULTIVARS ON GROWTH, YIELD AND QUALITY ATTRIBUTES OF GREEN GRAM

Singh *et al.* (2013) reported significant interaction between tillage management practices and genotypes or varieties. They also reported variable response of the same variety under different tillage management option, greatly influenced by the preceding tillage practices.

The interaction effects of grain yield of soybean between methods of tillage and different cultivars were not significant (Omondi *et al.,* 2014). Imran *et al.* (2016) reported that plant height, yield, yield attributes and protein content of greengram were significantly affected by cultivars, various phosphorous levels and tillage systems.

2.5 INFLUENCE OF TILLAGE METHODS AND CULTIVARS ON SOIL FERTILITY

Pulses play an important role in improving soil health, long term fertility and sustainability of the cropping systems. It meets N requirement through biological nitrogen fixation and left substantial amount of residual nitrogen and organic matter for subsequent crops. Using legumes in crop rotations to enhance soil fertility and crop production is one of the oldest agricultural management practices.

Tillage alters the physical, chemical and biological properties of soil and thus it is an agricultural practice of particular interest. Improved soil physical properties and consequent increases in crop productivity are the benefits associated with conservation agriculture. The increased amount of crop residues remaining on the surface under conservation tillage improves the soil physical and biological characteristics which results in increased soil fertility and soil quality (Andrade *et al*., 2003).

Alam (2014) reported that after four cropping cycles of wheat-mungbean-rice cropping system under subtropical climatic conditions, the highest organic matter accumulation, maximum root mass density (0–15 cm soil depth) and improved physical and chemical properties were recorded in conservational tillage practices. Tillage practices showed positive effects on soil properties and crop yields. According to Busari *et al*. (2015), zero or minimum tillage is beneficial to soil physical improvement as process of soil physical degradation normally sets in immediately after conventional tillage. Research reports indicated that conservation tillage, particularly minimum tillage, is better than conventional tillage in terms of soil improvement.

Thomas *et al.* (2007) observed greater organic matter accumulation and solute movement in soil under no tillage practice and found it beneficial to soil chemical and physical condition for long term crop production. Bilalis *et al.* (2010) observed that the soil organic matter and total nitrogen were higher in soils subjected to conservation tillage systems (minimum or no tillage) than under conventional tillage. Seed yield was also higher under minimum tillage than conventional tillage. Gan (2015) studied the crop rotations with pulses in rainfed areas.The results revealed that inclusion of pulses increased total grain production by 36 per cent, improved protein yield by 51 per cent and enhanced fertilizer-N use efficiency by 33 per cent over summer fallow system. Diversifying cropping systems with pulses can serve as an effective alternative to summer fallowing in rainfed dry areas.

Zero tillage practices can have beneficial impacts on productivity as well as minimizing environmental degradation such as soil erosion in legume and cereal crop growing areas (Das *et al*., 2014). Ahmad *et al*. (2017) found that among the tillage management practices, higher microbial activity, nodulation and nutrient uptake were obtained with conventional tillage which was followed by minimum and zero tillage methods. Sidar (2017) revealed that in finger millet grains significant effect on N uptake in summer plouging and P uptake in minimum tillage was noticed. In straw, N uptake was significantly affected in summer plouging while N content was higher in conventional tillage, P and K content were not significant in tillage practices.

Halvorson *et al.* (2001) reported that soil carbon sequestration has increased when tillage intensity has decreased. The study also revealed that tillage provides an oxidative environment which improves the decomposition of crop residues and soil organic matter. Meena *et al*. (2015) revealed that soil carbon content increased by 16-27 per cent in zero tillage over conventional tillage. Cultivation of greengram and its incorporation in rice fallow improves the organic carbon and NPK content in soil (Sharma *et al*. 2000).

Anikwe *et al*. (2007) noticed that soil bulk density was lower in the tilled plot compared to that of no-tilled plots. Soil physical properties was influenced by tillage methods and was noted higher soil moisture content and lower bulk density with increase in tillage operations and higher organic carbon content with minimum tillage practices (Khurshid *et al.*, 2006).

Tillage increases the shape, size and continuity of soil pores. Also soil temperature was decreased with decrease in ploughing at 07.00 and increased at 14.00 (Sarkar and Singh, 2007). Soil structural stability and carbon sequestration can be enhanced by long term use of conservation tillage and application of crop residues (Kahlon *et al.,* 2013).

When nitrogen was applied in three splits, the nitrogen uptake in zero till wheat was lower than conventionally tilled wheat with crop residues removed (Pasricha *et al.*, 2006). Minimum tillage in maize resulted in lower uptake of nitrogen and higher uptake of phosphorus compared to conventional tillage practice (Sharpe *et al.*, 1986). Huang *et al.* (2016) recorded 17- 43 per cent lower NPK uptake by rice plants in no-tilled plots than conventional tillage.

Using legumes in crop rotations to enhance soil fertility and crop production is one of the oldest agricultural management practices. Porpavai *et al.* (2011) reported that legumes in rice based cropping system increased the yield of succeeding crop of rice and the inclusion of legumes resulted in maximum organic carbon build up. The use of no-tillage management together with a moderate amount of crop residue (33%) rapidly improved the soil organic carbon (Roldan *et al.*, 2003).

Among summer legumes, the highest improvement in system productivity was recorded with greengram followed by fodder cowpea and blackgram (Kumar *et al.,* 2012). Including greengram in the crop rotation system has diversified and strengthened the cropping system, alleviated the disadvantage of the cereal–cereal cropping system and improved the productivity of the soil. It also increased the yield of paddy and the income of farmers (Weinberger, 2003).

2.6 EFFECT OF TILLAGE METHODS AND CULTIVARS ON ECONOMICS OF GREENGRAM

Zero tillage in cereal system had helped in saving fuel, water, reduce cost of production, improving system productivity and soil health (Jat *et al.*, 2009), whereas Pathak *et al.* (2011) noticed that intensive tillage and crop establishment require a higher amount of labour and water, resulting in rise in cost of cultivation.

Economic evaluation is necessary for the sustainability of any developed technology. Samant (2014) evaluated few greengram varieties and reported that the cultivation of HYV green gram OBGG 52 resulted in maximum gross and net returns and benefit cost ratio (2.21) which was followed by OUM 11-5, IPM 02-14 and Pant M-5 which were comparable. The local variety Kala mung recorded lowest net returns due to its lower productivity. Hence, the existing local variety can be replaced by HYV which fits to the existing farming system for higher productivity and income.

Behera *et al.* (2014) studied the effect of conservation agricultural practices on greengram (*Vigna radiata* L.) after the harvest of rice by utilizing the residual soil moisture. The study revealed that the grain yield, stover yield, yield attributes, system productivity and economics were significantly improved with conservation tillage practices with the maximum grain, stover yield, system productivity and net returns. Tamang *et al.* (2015) observed that most of the herbicides used in greengram were found effective in controlling weeds and they were at par with hand weeding twice. Hand weeding treatments, though significantly reduced weed biomass and improved the grain yield, gave less benefit: cost ratio owing to higher cost of farm labour. The cultivation of crops like pulses and oilseeds during summer season in command area provides additional income to farmers. Growing of these crops under zero tillage proved their worthiness in economic point of view (Huggi and Kalaghatagi, 2016). The higher monetary gain from these three varieties was due to their higher seed and straw yields. On the other hand, performance of the varieties like TJM 234 and SL 688 were poor. Shakya (2016) revealed that, among the greengram varieties, TARM 18 proved highly profitable giving net income up to Rs 39874.88 per ha with B: C ratio of 4.24. The other best varieties were HUM 12 and TM 99-50, which gave net income of Rs. 35243.88 per ha and Rs. 30018.36 per ha with B: C ratio 3.94 and 3.72, respectively.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was undertaken with the objectives to assess the response of selected greengram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage. The experiment was conducted during the period from December 2017 to March 2018 at Agronomy Farm, College of Horticulture, Vellanikkara.

The details of materials used and methods adopted for the study are described below.

3.1 EXPERIMENTAL SITE

The experiment was conducted in the summer rice fallows of *Kotteppadam* field under the Department of Agronomy, College of Horticulture, Vellanikkara. The experimental field is located at 10^0 31'N latitude and76^0 13'E longitude and an altitude of 40.3m above mean sea level. The experimental area was under rice crop during previous season.

3. 2 SOIL

The soil of the experiment site is sandy loam and acidic in nature. The soil belongs to the taxonomical order *Entisol*. The physico-chemical properties of the soil are presented in Table 3.1 and 3.2.

Table 3.1 Mechanical composition and physical characteristics of the soil

Particulars	**Value**	**Method adopted**
A. Mechanical composition		
Sand (%)	68.83	International pipette method (Piper, 1967)
Silt (%)	16.27	
Clay (%)	14.90	
Textural class	Sandy loam	
B. Soil physical characteristics		
Particulars	Soil depth (0-30 cm)	Method adopted
Particle density (Mg m^{-3})	2.61	Pycnometer method (Black, 1965)
Bulk density (Mg m^{-3})	1.45	Core method (Gupta and Dakshinamoorthi, 1980)
Porosity (%)	43.00	
Field capacity (%)	14.40	Pressure plate membrane apparatus (Dastane, 1967)
Permanent wilting point (%)	4.5	

Table 3.2 Chemical characteristics of soil prior to experiment

Particulars	**Value**	**Method adopted**
Soil reaction (pH)	5.26	pH meter with glass electrode (Jackson, 1973)
Organic C (%)	1.23	Walkley and Black rapid titration method (Jackson, 1973)
Available N (kg ha^{-1})	88.2	Alkaline Permanganate method (Subbiah and Asija, 1956)
Available P (kg ha^{-1})	12.54	Bray's colorimetric method (Jackson, 1973)
Available K (kg ha^{-1})	111.44	Ammonium acetate method (Jackson, 1973)

3.3 SEASON AND CLIMATE

The experiment was conducted in summer rice fallow after the harvest of rice during December 2017 to March 2018. The data on weather parameters (monthly rainfall, number of rainy days per month, maximum temperature, minimum temperature, relative humidity, evaporation and sunshine hours) during the cropping period are presented in Fig.1.

3.4 PLANTING MATERIAL

Seeds of greengram cultivars (CO 6, CO 7 and CO 8) were obtained from Tamil Nadu Agricultural University, Coimbatore and of cultivar VBN (Gg) 2 from National Pulses Research Centre, Vamban. They were used as the planting material.

3.5 MANURES AND FERTILIZERS

Farm yard manure (0.4 per cent, 0.2 per cent, 0.2 per cent N, P_2O_5 and K_2O, respectively) was used for the experiment. Urea (46 per cent N), Mussoriphos (20 per cent P_2O_5) and Muriate of potash (60 per cent K_2O) were used as a source of nitrogen (N), phosphorus (P) and potassium (K) respectively.

3.6 METHODS

1. Experimental Design and Layout

Layout plan of the experiment is presented in Fig. 2.

Design : Split plot
Replication : 3
Treatments : 16
Plot size : 3 m x 3m
Spacing : 25 cm x 15 cm

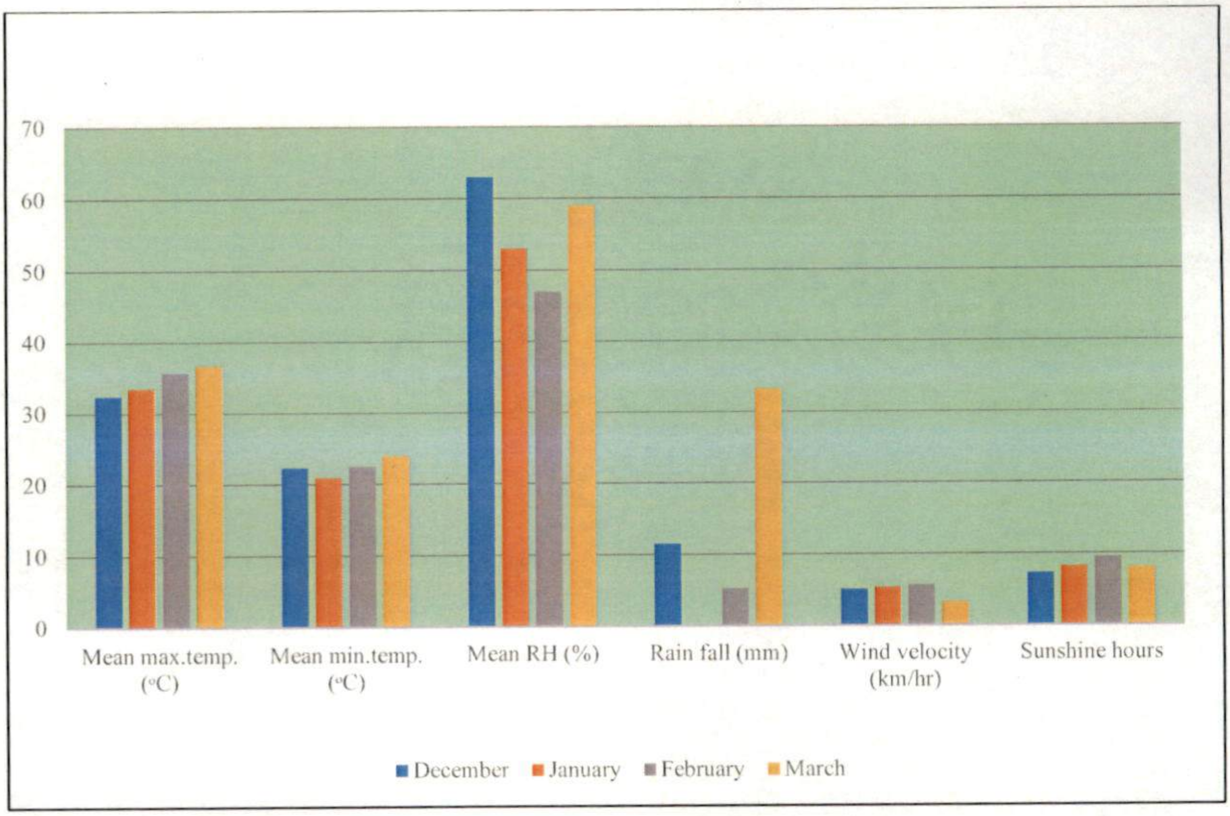

Fig. 1 Weather data during the crop period (December-2017 to March-218)

N

← 3m → **Replication 1**

↕ 3m

M_1V_1	M_1V_2	M_1V_3	M_1V_4
M_2V_4	M_2V_1	M_2V_2	M_2V_3
M_3V_3	M_3V_4	M_3V_1	M_3V_2
M_4V_3	M_4V_2	M_4V_4	M_4V_1

Replication 2

M_3V_4	M_3V_3	M_3V_1	M_3V_2
M_4V_3	M_4V_2	M_4V_4	M_4V_1
M_2V_2	M_2V_1	M_2V_3	M_2V_4
M_1V_1	M_1V_4	M_1V_2	M_1V_3

Replication 3

M_2V_4	M_2V_3	M_2V_2	M_2V_1
M_4V_3	M_4V_2	M_4V_1	M_4V_4
M_3V_1	M_3V_4	M_3V_3	M_3V_2
M_1V_2	M_1V_1	M_1V_4	M_1V_3

Fig.2 Layout of the experimental field

M_1- Minimum tillage
M_2- Minimum tillage *fb* pendimethalin
M_3- Minimum tillage *fb* imazethapyr + imazamox
M_4- Conventional tillage + two hand weedings

V_1 -CO 6
V_2 -CO 7
V_3 -CO 8
V_4 -VBN (Gg)2

Plate 1. Layout and land preparation

a. Minimum tillage plot

b. Conventional tillage plot

Plate 2. Types of tillage

Plate 3. Field view at sowing

Plate 4. Field view at 30 DAS

Plate 5. Field view at reproductive stage

Plate 6. Field view at the time of maturity

Plate 7. Field view at the time of harvest

2. Treatments

i. Main Plot Treatments

Tillage methods (M) - 4

M_1: Minimum tillage (primary tillage only)

M_2: Minimum tillage + pendimethalin @ 1kg ha^{-1}

M_3: Minimum tillage + imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS

M_4: Conventional tillage (primary and secondary tillage + two hand weedings at 15 and 30 DAS)

ii. Sub Plot Treatments

Four cultivars (V)

V_1 : CO 6
V_2 : CO 7
V_3 : CO 8
V_4 : VBN (Gg) 2

Treatment combinations - 16 (4x4)

T_1- M_1V_1
T_2- M_1V_2
T_3- M_1V_3
T_4- M_1V_4
T_5- M_2V_1
T_6- M_2V_2
T_7- M_2V_3
T_8- M_2V_4
T_9 – M_3V_1
T_{10}- M_3V_2
T_{11}- M_3V_3
T_{12}- M_3V_4
T_{13}- M_4V_1
T_{14}- M_4V_2
T_{15}- M_4V_3
T_{16}- M_4V_4

In minimum tillage the field was ploughed only once and seed bed were taken with minimum soil disturbance with the previous rice crop residue. In conventional tillage, the field was ploughed three times thoroughly with tractor, followed by secondary tillage and seed beds were prepared without the crop residues.

3.7 CULTIVATION PRACTICES

1. Field Preparation

The experimental area was ploughed as per the treatments.

2. Application of Lime, Manures and Fertilizers

Lime and cowdung were applied as per the Package of Practice Recommendation (KAU, 2016) and incorporated with the soil. Urea, mussoriphos and muriate of potash (44, 150 and 50 kg ha^{-1}) were applied as per the package of practice recommendations (KAU, 2016).

3. Seeds and Sowing

Sowing was done on 14th December 2017. A seed rate of 20 kg ha^{-1} with a spacing of 25cm x 15cm was followed. The details of cultivars used were as follows:

Cultivars	**Sailent features**	**Source of seed**
CO 6	A derivative of the cross between WGG 37 x Co 5, resistant to yellow mosasic virus disease.	Tamil Nadu Agricultural University, Coimbatore
CO 7	A derivative of the cross between MGG 336 and COGG 902, high protein content (25.2%) and high seed weight and synchronized maturity.	Tamil Nadu Agricultural University, Coimbatore

CO 8	A derivative of the cross between COGG 923 and VC 6040A, resistant to yellow mosaic disease, stem necrosis and moderately resistant to root rot, moderately resistant to aphids and stem fly.	Tamil Nadu Agricultural University, Coimbatore
VBN (Gg) 2	High yielding greengram for all seasons. A derivative of the cross between VGG 4 and MH 309, Shiny grains, lobed leaves moderately resistant to yellow mosaic virus disease and pod borer. It matures in 65 to 70 days.	National Pulse Research Centre, Vamban

4. Weeding

Weeding was done as per the tillage methods. Minimum tillage (one ploughing with tractor) was practiced in three main plots (M_1, M_2 and M_3). Pre emergence application of pendimethalin @ 1 kg ha^{-1} on 3 days after sowing using Knapsack sprayer fitted with flat fan nozzle using 500 litres of water for spraying one ha in main plot treatments, M_2. Minimum tillage followed by the application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS which was practiced in main plot treatments, M_3. In conventional tillage (primary and secondary tillage) plots, two hand weedings were done at 15 and 30 DAS. The details of herbicides used were given below.

Generic name and strength of formulation	Chemical class	Method of application
Pendimethalin 30 EC	Dinitroanilines	Pre emergence
Imazethapyr 35% + imazamox 35% w/w WG (70 WG)	Imidazolinone	Post emergence

5. Gap filling

Gap filling was done after two weeks of sowing to maintain the optimum plant population.

6. Harvesting

First harvesting was done at 19th February 2018 when the mature pods started to blacken. On 27th February 2018, second harvesting was done. First two successive harvesting was done by picking the dried pods with hands and the third harvesting was done on 5th March 2018 by pulling out the whole plant. After drying, pods were threshed by beating with sticks and separated.

7. Plant protection

Aphid attack was noticed irrespective of treatments at flowering and the same is controlled by spraying thiamethoxam @ 25 g ha^{-1}. Pod borer was also observed in field. It is controlled by manual picking and destroying the pods as the damage was minimum in field. Powdery mildew disease was noticed in all treatments and it was controlled by spraying mancozeb @ 0.3 per cent.

3.8 OBSERVATIONS

Observations on growth characters, physiological parameters, yield and yield attributing characters of greengram were recorded and the mean values were worked out.

Sampling procedure

Observations on growth characters were taken from five plants from each plot at 30 days after sowing (DAS), at flowering and at harvest. After elimination of border plants, five plants were selected randomly as observational plants. At harvest, these five observational plants were used for dry matter estimation and chemical analysis.

3.8.1 Crop Growth Characters

Crop growth characters were recorded at 30 DAS, flowering and harvest.

i. Height of the plant

The height of the plant was measured from the ground level to the growing up of the observational plants and expressed in cm.

ii. Number of leaves per plant

The number of fully opened trifoliate leaves were counted from the observational plants and mean was worked out.

iii. Number of branches per plant

The number of branches per plant was computed from the observational plants and the mean was worked out.

iv. Total leaf area per plant

Total leaf area was measured by multiplying average number of leaves and average leaf area of lower, middle and upper leaves.

LA=k (L * W)

Where k is Kemp's constant (for dicot leaves=0.66)

Total leaf area = Average leaf area of plant x average number of leaves

v. Days to 50 per cent flowering

It was calculated by counting the average number of days taken by 50 per cent of plants for the emergence of flowers in each treatment were noted and recorded

vi. Dry matter production

Dry matter of the plant was recorded at 30 DAS, at flowering and at harvest by destructive sampling of three random plants. These plants were uprooted from each plot carefully without damaging the roots. The plants were dried under shade and then oven dried at 70 ± 5°C till consecutive weights obtained. The dry weight of the plants were found out and expressed as (g/plant).

3.8.2 Physiological Parameters

Crop growth characters were recorded at 30 DAS, flowering, 60 DAS and harvest.

i. Crop growth rate (CGR) (g/ m^2/ d)

CGR was calculated by the formula suggested by

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

Where,

W_1: Initial dry weight
W_2: Final dry weight
t_1: Initial time
t_2: Final time
P: Land area

ii. Relative growth rate (RGR) **(g /g /d)**

$$\text{RGR} = \frac{\text{Loge } W_2 - \text{loge } W_1}{t_2 - t_1}$$

Where,

W_1: Initial dry weight
W_2: Final dry weight
t_1: Initial time
t_2: Final time

iii. Net assimilation rate (NAR) **(g/ cm²/ d)**

$$\text{NAR} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\log_e A_2 - \log_e A_1}{A_2 - A_1}$$

Where,

A_1: Total leaf area at initial time (t_1)
A_2: Total leaf area at final time (t_2)
W_1: Initial dry weight
W_2: Final dry weight

iv. Leaf area index (LAI)

Leaf area index (LAI) was worked out using the formula suggested by Watson (1947).

$$\text{Leaf area index} = \frac{\text{Total functional leaf area plant}^{-1}}{\text{Land area occupied plant}^{-1}}$$

v. Leaf area duration (LAD)

Leaf area duration was determined by the formula (Power *et al.*, 1967).

$$\text{LAD} = \frac{\text{LAI}_1 + \text{LAI}_2}{2} \times (t_2 - t_1)$$

Where,

LAI_1 = Leaf area index at the first stage

LAI_2 = Leaf area index at the second stage

$t_2 - t_1$ = Time period between the first and second stages

3.8.2.6 Number of nodules per plant

The number of nodules from three random plants were counted at 30 DAS, at flowering and at harvest. The average of three plants was worked out and recorded.

3.8.3 Yield and Yield Attributes

i. Number of pods per plant

Total number of pods from observational plants from each plot were counted and averaged to get number of pods plant.$^{-1}$

ii. Length of pod (cm)

Length of pods were recorded from fifteen randomly selected pods of observational plants and average was worked out to get pod length, expressed in cm.

iii. Number of seeds per pod

Number of seeds from fifteen randomly selected pods of observational plants were counted and averaged to get number of seeds pod^{-1}.

iv. Seed weight (g)

From the seed obtained from the observational plants, 100 seeds were counted, oven dried and their weights recorded and expressed in grams.

v. Seed yield

Seed yield per plot was recorded after threshing and winnowing from each net plot area. The seed yield per hectare was worked out and expressed in kg ha^{-1}.

vi. Biological yield

This was estimated by adding the weight of seed and stover after complete sun drying, obtained from each net plot and expressed in kg ha^{-1}.

vii. Harvest index

Harvest index was calculated by dividing the weight of seeds with the total weight of seeds and stover of each plot (Singh and Stoskopf, 1971)

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.8.4 Observation on Weeds

i. Weed population per m^2

Weeds from randomly taken 1m^2 area in each plot were counted as species wise and recorded during 30 DAS, at flowering and at harvest.

ii. Weed dry weight per m^2

Weeds were uprooted from sampling area of each plot, dried in shade and then in hot air oven at 70°C and dry weight was recorded and expressed in gm^{-2}

3.8. 5 Quality Analysis

i. Protein content of the seed (%)

Nitrogen content in seeds of greengram were analysed and percentage protein in the seed was calculated by multiplying the percentage of nitrogen with the factor 6.25 (Simpson *et al.*, 1965).

3.9 Soil Analysis

After the harvest of greengram, soil samples were collected from individual plots of the experimental area and analyzed for organic carbon, available N, P and K as per the standard procedures mentioned in Table 3.2.

3.10 Plant Chemical Analysis

The plants at harvest were analysed for nitrogen, phosphorus and potassium. The samples were dried to constant weight in an electric hot air oven at 70 ± 5°C, ground into fine powder and used for chemical analysis. The procedure adopted for the chemical analysis are given in table.

Plant nutrient status estimation

Particulars	Method used	Reference
N (%)	Modified micro kjeldahl method	(Jackson, 1973)
P (%)	Vanado-molybdo phosphoric yellow colour method using spectrophotometer	(Jackson, 1973)
K (%)	Flame photometry method	(Jackson, 1973)

Uptake of nutrients at harvest was calculated from the values of dry matter content and per cent nutrient content of plant and expressed as g plant^{-1} and kg ha^{-1}.

3.11 Incidence of Major Pests and Diseases

Incidence of major pest and diseases during crop period was observed and recorded.

3.12 Cost Benefit Analysis

i. Cost of Cultivation

Cost of cultivation under different irrigation and nutrient levels were calculated and expressed in ₹ ha $^{-1}$.

ii. Gross Income

Gross income was calculated on the basis of market price of the produce and expressed in ₹ ha^{-1}.

iii. Net Income

Net income was calculated by subtracting cost of cultivation from gross income and is expressed in ₹ ha^{-1}.

iv. Benefit Cost Ratio (BCR)

BCR was worked out as the ratio of gross income to cost of cultivation.

$$\text{BCR} = \frac{\text{Gross income (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

3.13 Statistical Analysis

The data was analyzed statistically by applying the techniques of analysis of variance (Gomez and Gomez, 1984). Wherever the effects were found to be significant, critical differences were given for effective comparison among the mean. The Correlation of yield of greengram with growth and yield parameters were also computed.

RESULTS

4. RESULTS

An experiment entitled "Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods" was undertaken to study the response of selected greengram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage. The experiment was conducted during the period from December 2017 to March 2018 at Agronomy Farm, College of Horticulture, Vellanikkara. The experimental data collected were statistically analysed and the results are presented below.

4.1. GROWTH PARAMETERS

The data on growth attributes as influenced by different tillage methods and cultivars during the crop period are presented below. The observations were recorded at 30 days after sowing (DAS), at flowering and at harvest.

4.1.1 Plant Height

The mean plant height recorded at various growth stages are given in Table 4.1.

A critical appraisal of data during the study revealed that the treatments significantly influenced the plant height of greengram. During the crop period, at 30 DAS, plant height was not influenced by tillage methods. But at flowering stage, tillage methods significantly influenced the plant height and the plants were taller (32.42 cm, 32.12 cm) in minimum tillage *fb* imazethapyr + imazamox (M_3) and in conventional tillage *fb* two hand weedings (M_4), respectively. The shortest (27.67 cm) plants were observed in minimum tillage (M_1). At harvest stage, conventional tillage + two hand weedings (M_4) and minimum tillage *fb* imazethapyr + imazamox (M_3) were on a par and significantly superior to the other two tillage methods. The shortest plants (33.24 cm) were observed in minimum tillage (M_1) and were inferior to all other methods.

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The cultivars differed significantly with respect to plant height at all stages of growth. A perusal of data revealed the superiority of cultivar CO 8 (V_3) at flowering and harvest stage. At 30 DAS, the cultivars CO 8 (V_3) and VBN (Gg)2 (V_4) were taller and were superior to the cultivars CO 6 (V_1) and CO 7 (V_2). At flowering and at harvest stages, the cultivar CO 8 (V_3) was the tallest (33.87 cm and 44.74 cm, respectively) and was superior to the other three cultivars. The cultivars CO 6 (V_1) and CO 7 (V_2) were at par and were inferior to the other two cultivars. Plant height varied from 33.16 cm in CO 6 (V_1) to 44.74 cm in CO 8 (V_3) at harvest stage. The tillage x cultivar interactions were not significant at any stages during the study.

4.1.2 Number of Leaves

The analysed data are presented in Table 4.2. The results revealed that the treatments had no significant influence on number of leaves at any of the growth stages.

The interaction effects were also found not significant.

4.1.3 Number of Branches

The data on mean number of branches is given in Table 4.3. The methods of tillage did not influence the number of branches at 30 DAS. However the cultivars significantly differed with respect to the number of branches at 30 DAS. The cultivar CO 8 (V_3) recorded higher (3.49) number of branches, at par with CO 6 (V_1) and VBN (Gg)2 (V_4). The cultivar CO 7 (V_2) recorded the lowest value (2.98).

At flowering and at harvest, branching was influenced by tillage methods. More number of branches were recorded in minimum tillage *fb* pendimethalin (M_2) and minimum tillage *fb* imazethapyr + imazamox (M_3). They were at par and were superior to the other two methods of tillage. The branching was not influenced by the cultivars at these stages.

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The interaction effects were also not found significant.

4.1.4 Total Leaf Area

Total leaf area at various growth stages are presented in Table 4.4.

The tillage methods had significant influence on total leaf area at flowering and harvest stage. Minimum tillage *fb* imazethapyr + imazamox (M_3) recorded higher leaf area (1089.02 cm^2 and 720.43 cm^2) at flowering and harvest stage, respectively which was at par with conventional tillage (M_4). The lower leaf area (824.57 cm^2 and 489.57 cm^2) were recorded at flowering and harvest stage, respectively in minimum tillage (M_1) was at par with minimum tillage *fb* pendimethalin (M_2).

The cultivars showed significant difference in leaf area both at 30 DAS and at maturity. The cultivar CO 8 (V_3) recorded higher leaf area (207.97 and 679.55 cm^2) at 30 DAS and at harvest, respectively.

The interactions were found not significant at all growth stages.

4.1.5 Days to 50 per cent flowering

The mean numbers of days to 50 per cent flowering are given in Table 4.12.

There was no significant difference in the number of days taken for 50 per cent flowering with respect to tillage methods and cultivars. The interaction effect was also found non-significant. Days to 50 per cent flowering varied from 43 to 47 days during the experiment.

Table 4.3 Effect of tillage methods and cultivars on the height of greengram, cm

Treatments	**30 DAS**	**Flowering**	**Maturity**
Tillage methods (M)			
M_1 -Minimum tillage	15.06	27.67	33.24
M_2 -Minimum tillage *fb* pendimethalin	14.86	30.72	35.48
M_3 -Minimum tillage *fb* imazethapyr + imazamox	14.30	32.42	38.98
M_4 -Conventional tillage + two hand weedings	14.13	32.12	39.01
SEm (±)	0.600	0.471	0.63
CD (0.05)	NS	1.66	2.22
Cultivars (V)			
V_1 -CO 6	13.99	29.00	33.16
V_2 -CO 7	13.85	29.05	36.41
V_3 -CO 8	15.23	33.78	44.74
V_4 -VBN (Gg)2	15.29	31.11	41.72
SEm (±)	0.427	0.786	0.812
CD (0.05)	1.25	2.31	2.38

Table 4.4 Effect of tillage methods and cultivars on number of leaves of greengram

Treatments	30 DAS	Flowering	Maturity
Tillage methods (M)			
M_1 -Minimum tillage	3.40	8.29	5.17
M_2 -Minimum tillage *fb* pendimethalin	3.52	8.91	5.61
M_3 -Minimum tillage *fb* imazethapyr + imazamox	3.62	9.42	6.06
M_4 -Conventional tillage + two hand weedings	3.47	9.42	5.83
SEm (±)	0.08	0.25	0.18
CD (0.05)	NS	NS	NS
Cultivars (V)			
V_1 -CO 6	3.36	8.87	5.47
V_2 -CO 7	3.35	8.99	5.49
V_3 -CO 8	3.72	9.19	5.91
V_4 -VBN (Gg)2	3.59	8.99	5.80
SEm (±)	0.11	0.17	0.16
CD (0.05)	NS	NS	NS

Table 4.5 Effect of tillage methods and cultivars on number of branches of greengram

Treatments	30 DAS	Flowering	Maturity
Tillage methods (M)			
M_1 -Minimum tillage	3.32	4.78	5.49
M_2 -Minimum tillage *fb* pendimethalin	3.32	5.17	5.97
M_3 -Minimum tillage *fb* imazethapyr + imazamox	3.41	5.10	6.00
M_4 -Conventional tillage + two hand weedings	3.17	4.73	5.72
SEm (±)	0.10	0.09	0.06
CD (0.05)	NS	0.31	0.21
Cultivars (V)			
V_1 -CO 6	3.40	4.79	5.67
V_2 -CO 7	2.98	4.86	5.64
V_3 -CO 8	3.49	5.12	5.92
V_4 -VBN (Gg)2	3.33	5.02	5.95
SEm (±)	1.09	0.19	0.16
CD (0.05)	0.32	NS	NS

Table 4.6 Effect of tillage methods and cultivars on leaf area of greengram, cm^2

Treatments	**30 DAS**	**Flowering**	**Maturity**
Tillage methods (M)			
M_1 -Minimum tillage	181.74	824.57	489.57
M_2 -Minimum tillage *fb* pendimethalin	188.14	942.16	598.26
M_3 -Minimum tillage *fb* imazethapyr + imazamox	201.46	1089.02	720.43
M_4-Conventional tillage + two hand weedings	183.81	1078.77	658.68
SEm (±)	13.42	41.36	33.99
CD (0.05)	NS	145.91	119.92
Cultivars (V)			
V_1 -CO 6	173.24	931.15	551.11
V_2 -CO 7	169.94	950.68	549.46
V_3 -CO 8	207.97	1030.25	679.55
V_4 -VBN (Gg)2	204.01	1022.44	686.83
SEm (±)	8.43	39.70	31.95
CD (0.05)	24.76	NS	93.82

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4.2 PHYSIOLOGICAL PARAMETERS

4.2.1 Crop Growth Rate (CGR)

The data revealed that CGR varied with tillage methods and cultivars (Table 4.5). The CGR values increased up to 60 DAS and thereafter declined till maturity. At all growth stages, minimum tillage *fb* imazethapyr + imazamox (M_3) and conventional tillage (M_4) were at par and found superior to minimum tillage (M_1) and minimum tillage *fb* pendimethalin (M_2). The cultivar CO 8 (V_3) and VBN (Gg)2 (V_4) recorded higher CGR at all the growth stages and superior to CO 6 (V_1) and CO 7 (V_2).

The interaction effects were not found significant.

4.2.2 Relative Growth Rate (RGR)

The values of RGR showed a decreasing trend as crop advanced in age (Table 4.6). The results revealed that the influence of tillage methods and cultivars on RGR was not significant.

All interactions were found not significant.

4.2.3 Net Assimilation Rate (NAR)

The net assimilation rate (NAR) recorded at various growth stages are presented in Table 4.7.

The results revealed that the influence of tillage methods and cultivars on NAR was not significant. In all the treatments, NAR showed a decreasing trend till the crop reached the harvesting stage.

All interactions were found to be non-significant.

4.2.4 Leaf Area Index (LAI)

The leaf area index (LAI) recorded at various growth stages are presented in Table 4.8.

Leaf area index at flowering and at harvest were significantly influenced by the methods of tillage. The results revealed that minimum tillage *fb* imazethapyr + imazamox (M_3) and conventional tillage (M_4) were at par and recorded higher leaf area index at flowering (2.90, 2.87) and at harvest (1.92, 1.75), respectively. The minimum tillage (M_1) recorded the lower LAI at all growth stages and it was at par with minimum tillage *fb* pendimethalin (M_2).

The LAI varied significantly among cultivars at 30 DAS and at harvest. The cultivars CO 8 (V_3) and VBN (Gg)2 (V_4) were on par at 30 DAS and at harvest and were superior to CO 6 (V_1) and CO 7 (V_2).

The interaction effects were found to be non-significant.

4.2.5 Leaf Area Duration (LAD)

The tillage methods significantly influenced the LAD at flowering and at harvest (Table 4.9). Combination of minimum tillage practices with herbicide sprays (M_2 andM_3) and conventional tillage methods *fb* hand weedings (M_4) were on par and significantly superior to minimum tillage (M_1) at flowering stage. At maturity, minimum tillage *fb* imazethapyr + imazamox (M_3) recorded higher LAD (36 days) which was on par with conventional tillage (M_4).The lowest duration (26 days) was recorded in minimum tillage (M_1) plots.

The results revealed that the cultivars vary significantly with respect to LAD at all growth stages. At maturity, minimum tillage *fb* imazethapyr + imazamox (M_3) recorded higher LAD (36 days) which was on a par with conventional tillage (M_4).The cultivar CO 8 (V_3) recorded higher LAD which was at par with VBN (Gg)2 (V_4) at all growth stages.

The interaction effects were found not significant.

4.2.5. Number of Nodules

The data showed that the number of nodules was significantly influenced by the tillage methods and cultivars (Table 4.10). It is obvious from the results that the number of nodules increased up to flowering stage and thereafter declined at maturity. The results revealed that minimum tillage *fb* pendimethalin (M_2), minimum tillage *fb* imazethapyr + imazamox (M_3) and conventional tillage (M_4) were at par and superior to minimum tillage (M_1) at 30 DAS. At flowering and maturity M_3 and M_4 were at par and superior to M_1 and M_2.

The number of nodules was influenced by cultivars only at flowering stage. At this stage CO8 (V_3) and VBN (Gg)2 (V_4) recorded the values of 19.40 and 18.76, respectively and were superior to cultivars CO 6 (V_1) and CO 7 (V_2).

All interactions were found non-significant.

Table 4.7 Effect of tillage methods and cultivars on crop growth rate (CGR) of greengram, g $m^{-2}d^{-1}$

Treatments	**At 30 DAS**	**At flowering**	**At 60 DAS**	**At maturity**
Tillage methods (M)				
M_1 -Minimum tillage	0.99	2.70	11.11	6.89
M_2 -Minimum tillage *fb* pendimethalin	1.10	2.92	15.92	7.97
M_3 -Minimum tillage *fb* imazethapyr + imazamox	1.48	3.07	20.29	9.17
M_4 -Conventional tillage + two hand weedings	1.55	3.09	17.83	8.78
SEm (±)	0.09	0.14	0.95	0.63
CD (0.05)	0.32	NS	3.35	NS
Cultivars (V)				
V_1 -CO 6	1.11	2.86	14.35	7.11
V_2 -CO 7	1.19	2.76	15.20	7.81
V_3 -CO 8	1.51	3.14	18.40	9.34
V_4 -VBN (Gg)2	1.29	3.00	17.21	8.54
SEm (±)	0.09	0.14	0.93	1.12
CD (0.05)	0.27	NS	2.75	NS

Table 4.8 Effect of tillage methods and cultivars on relative growth rate (RGR) of greengram, g $g^{-1}d^{-1}$

Treatments	At 30 DAS	At flowering	At maturity
Tillage methods (M)			
M_1 -Minimum tillage	0.063	0.036	0.011
M_2 -Minimum tillage *fb* pendimethalin	0.064	0.036	0.010
M_3 -Minimum tillage *fb* imazethapyr + imazamox	0.067	0.031	0.009
M_4 -Conventional tillage + two hand weedings	0.072	0.030	0.010
SEm (±)	0.004	0.002	0.001
CD (0.05)	NS	NS	NS
Cultivars (V)			
V_1 -CO 6	0.067	0.035	0.010
V_2 -CO 7	0.063	0.033	0.010
V_3 -CO 8	0.069	0.032	0.010
V_4 -VBN (Gg)2	0.067	0.034	0.010
SEm (±)	0.003	0.002	0.001
CD (0.05)	NS	NS	NS

Table 4.9 Effect of tillage methods and cultivars on net assimilation rate (NAR) of greengram, g cm^{-1} d^{-1}

Treatments	At 30 DAS	At flowering	At maturity
Tillage methods (M)			
M_1 -Minimum tillage	9.07	4.59	0.72
M_2 -Minimum tillage *fb* pendimethalin	9.82	4.24	0.99
M_3 -Minimum tillage *fb* imazethapyr + imazamox	12.68	3.90	1.13
M_4 -Conventional tillage + two hand weedings	14.37	3.85	1.08
SEm (±)	1.41	0.31	0.12
CD (0.05)	NS	NS	NS
Cultivars (V)			
V_1 -CO 6	10.33	4.21	1.01
V_2 -CO 7	11.51	3.97	0.97
V_3 -CO 8	13.08	4.29	0.97
V_4 -VBN (Gg)2	11.03	4.12	0.97
SEm (±)	0.87	0.28	0.09
CD (0.05)	NS	NS	NS

Table 4.10 Effect of tillage methods and cultivars on leaf area index (LAI) of greengram

Treatments	30 DAS	At flowering	At maturity
Tillage methods (M)			
M_1 -Minimum tillage	0.48	2.20	1.30
M_2 -Minimum tillage *fb* pendimethalin	0.50	2.51	1.59
M_3 -Minimum tillage *fb* imazethapyr + imazamox	0.53	2.90	1.92
M_4 -Conventional tillage + two hand weedings	0.49	2.87	1.75
SEm (±)	0.03	0.11	0.09
CD (0.05)	NS	0.39	0.31
Cultivars (V)			
V_1 -CO 6	0.46	2.48	1.46
V_2 -CO 7	0.45	2.53	1.46
V_3 -CO 8	0.55	2.74	1.81
V_4 -VBN (Gg)2	0.54	2.72	1.83
SEm (±)	0.02	0.10	0.08
CD (0.05)	0.06	NS	0.25

Table 4.11 Effect of tillage methods and cultivars on leaf area duration (LAD) of greengram, days

Treatments	15 to 30 DAS	At flowering (30 to 45)	At harvest (45 to 60)
Tillage methods (M)			
M_1 -Minimum tillage	10.96	20.12	26.28
M_2 -Minimum tillage *fb* pendimethalin	11.85	22.60	30.80
M_3 -Minimum tillage *fb* imazethapyr + imazamox	12.77	25.80	36.18
M_4 -Conventional tillage + two hand weedings	11.52	25.25	34.75
SEm (±)	0.98	1.01	1.19
CD (0.05)	NS	3.58	4.22
Cultivars (V)			
V_1 -CO 6	10.38	22.08	29.64
V_2 -CO 7	10.52	22.41	30.00
V_3 -CO 8	13.28	24.76	34.19
V_4 -VBN (Gg)2	12.92	24.52	34.18
SEm (±)	0.62	0.79	1.04
CD (0.05)	1.84	2.31	3.05

Table 4.12 Effect of tillage methods and cultivars on number of nodules

Treatments	**At 30 DAS**	**At flowering**	**At maturity**
Tillage methods (M)			
M_1 -Minimum tillage	9.70	17.12	7.12
M_2 -Minimum tillage *fb* pendimethalin	12.11	17.95	7.91
M_3 -Minimum tillage *fb* imazethapyr + imazamox	11.48	18.27	9.29
M_4 -Conventional tillage + two hand weedings	12.30	19.69	9.08
SEm (±)	0.43	0.44	0.28
CD (0.05)	1.55	1.57	1.00
Cultivars (V)			
V_1 -CO 6	10.66	17.05	7.91
V_2 -CO 7	11.39	17.82	8.16
V_3 -CO 8	12.05	19.40	8.83
V_4 -VBN (Gg)2	11.49	18.76	8.50
SEm (±)	0.46	0.53	0.24
CD (0.05)	NS	1.56	NS

4.3 YIELD AND YIELD ATTRIBUTES

4.3.1 Number of Pods per Plant

The number of pods per plant varied significantly due to methods of tillage and cultivars (Table 4.12). Minimum tillage *fb* imazethapyr + imazamox (M_3) recorded higher number of pods (22.14) and was on a par with conventional tillage + two hand weeding (M_4) and superior to the other tillage treatments. Among cultivars, CO 8 (V_3) recorded the highest number of pods per plant (22.39). The lowest number of pods was recorded in CO 6 (V_1) (15.46). However, the interaction of tillage methods and cultivars was not significant.

4.3.2 Length of Pod

The influence of methods of tillage on length of pod was found not significant (Table4.12). The conventional tillage (M_4) method recorded the higher value of pod length (8.40 cm) and the lower value was recorded in minimum tillage *fb* pendimethalin (M_2) (7.81 cm).

The influence of cultivars on pod length was found significant. The cultivar CO 8 (V_3) recorded the longest pod (8.68 cm) and was at par with CO 7 (V_2) (8.34) and VBN (Gg)2 (V_4) (8.06).The lowest value was recorded in the cultivar CO 6 (V_1) (7.31 cm) and significantly inferior to the other three cultivars.

All interactions were found not significant.

4.3.3 Number of Seeds per Pod

The data summarized in the Table 4.12 showed that the number of seeds per pod was significantly influenced by the methods of tillage and cultivars. The data revealed that the minimum tillage *fb* imazethapyr + imazamox (M_3) and conventional tillage (M_4) were at par and superior to minimum tillage (M_1) and minimum tillage *fb* pendimethalin (M_2). The minimum tillage *fb* imazethapyr + imazamox (M_3) recorded the highest value of 11.81 and minimum tillage (M_1) recorded the lowest value of 10.60.

The cultivar CO 8 (V_3) recorded the highest number of seeds per pod and was at par with VBN (Gg)2 (V_4). The lower number of seeds per pod were found in cultivar CO 7 (V_2) and CO 6 (V_1) (10.69 and 10.97), respectively.

The interactions were found to be not significant.

4.3.4 100 Seed Weight

The 100 seed weight was not influenced by the methods of tillage but cultivars differed significantly (Table 4.13). The higher 100 seed weight (3.75 g) was recorded by CO 8 (V_3) which was at par with CO 6 (V_2) and VBN (Gg)2 (V_4).

The interactions were found to be not significant.

4.3.5 Seed Yield

The data pertaining to yield are presented in the Table 4.14.

Yield of greengram was significantly influenced by tillage methods. Cultivars also differed significantly. Minimum tillage *fb* imazethapyr + imazamox (M_3) recorded the highest seed yield (748 kg ha^{-1}) and it was at par with conventional tillage + two hand weeding at 15 and 30 DAS (M_4) and these two were significantly superior over other two methods of tillage. The minimum tillage (M_1) recorded the lowest seed yield (370 kg ha^{-1}).

The cultivar CO 8 recorded significantly highest seed yield (736 kg ha^{-1}) compared to other three cultivars. It was followed by VBN (Gg)2 (V_4) with a seed yield of 644 kg ha^{-1}. The cultivars CO 6(V_1) and CO 7 (V_2) were at par with a seed yield of 492 kg ha^{-1} and 522 kg ha^{-1}.

The interaction between methods of tillage and cultivars was found to be significant. All cultivars recorded higher yield under minimum tillage followed by application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and conventional tillage followed by two hand weedings at 15 and 30 DAS. Among the treatment combinations, the highest seed yield (942 kg ha^{-1}) was recorded in M_3V_3 followed by M_4V_3 (911 kg ha^{-1}). The lowest yield (341 kg ha^{-1}) was observed in M_1V_1.

Under minimum tillage (M_1) there was no significant difference in yield was observed among the cultivars. In minimum tillage *fb* pendimethalin (M_2), the cultivar CO 8 recorded higher yield (697 kg ha^{-1}) and it was at par with VBN (Gg)2. The cultivar CO 6 recorded the lowest yield (410 kg ha^{-1}). The cultivar CO 8 recorded the highest yield (942 kg ha^{-1}) in minimum tillage *fb* imazethapyr + imazamox @ 80g ha^{-1} at 20 DAS. The lower yield (631 and 629 kg ha^{-1}) was observed with the cultivars CO 6 and CO 7, respectively. Under conventional tillage, CO 8 recorded the highest yield (911 kg ha^{-1}) and the lower yield were recorded by CO 6 and CO 7, respectively.

4.3.6. Biological yield

The results revealed that the biological yield was significantly influenced by the methods of tillage and cultivars (Table 4.15). The biological yield was higher (3127 kg ha^{-1}) in minimum tillage *fb* imazethapyr + imazamox (M_3) and was at par with conventional tillage (M_4) and were significantly differed from minimum tillage (M_1) and minimum tillage *fb* pendimethalin (M_2). The lowest biological yield (1792 kg ha^{-1}) was observed in minimum tillage (M_1). Similarly, among the cultivars, the biological yield was higher in CO 8 (V_3) (2902 kg ha^{-1}) and it was at par with VBN (Gg)2 (V_4). The lower value was observed with the cultivar CO 6 (V_1) and it was at par with CO 7 (V_2).

The interactions were found not significant.

4.3.7. Harvest Index

The results are given in Table 4.12

The treatment effects were not significant. The value of harvest index ranges from 0.19 to 0.26. The highest HI of 0.26 and 0.25 were recorded in conventional tillage (M_4) and cultivar CO 8 (V_3), respectively.

The interactions were found to be not significant.

4.4 QUALITY PARAMETER

4.4.1 Protein Content

The protein content was not significantly influenced by tillage methods and cultivars (Table 4.11). The protein content in different cultivars varied from 21.34 to 22.41 per cent in CO 8 and CO 7, respectively.

The interactions were found non-significant.

Table 4.13 Effect of tillage methods and cultivars on protein content of greengram

Treatments	Protein content (%)
Tillage methods (M)	
M_1 -Minimum tillage	21.84
M_2 -Minimum tillage *fb* pendimethalin	21.81
M_3 -Minimum tillage *fb* imazethapyr + imazamox	22.32
M_4 -Conventional tillage + two hand weedings	21.91
SEm (±)	0.16
CD (0.05)	NS
Cultivars (V)	
V_1 -CO 6	21.34
V_2 -CO 7	22.41
V_3 -CO 8	22.08
V_4 -VBN (Gg)2	22.06
SEm (±)	0.26
CD (0.05)	NS

Table 4.14 Effect of tillage methods and cultivars on the yield characters of greengram

Treatments	No. of pods/plant	Length of pod (cm)	No. of seeds/pod	Days to 50 per cent flowering	Harvest index
Tillage methods (M)					
M_1 -Minimum tillage	15.26	7.83	10.60	44.67	0.21
M_2 -Minimum tillage *fb* pendimethalin	15.87	7.81	10.99	45.25	0.23
M_3 -Minimum tillage *fb* imazethapyr + imazamox	22.14	8.36	11.81	45.50	0.24
M_4 -Conventional tillage + two hand weedings	21.72	8.40	11.57	44.50	0.26
SEm (±)	0.68	0.36	0.21	0.51	0.02
CD (0.05)	2.40	NS	0.75	NS	NS
Cultivars (V)					
V_1 -CO 6	15.46	7.31	10.97	45.58	0.22
V_2 -CO 7	17.40	8.34	10.69	44.75	0.23
V_3 -CO 8	22.39	8.68	11.71	44.42	0.25
V_4 -VBN (Gg)2	19.75	8.06	11.60	45.17	0.24
SEm (±)	0.74	0.23	0.18	0.43	0.01
CD (0.05)	2.18	0.69	0.53	NS	NS

Table 4.15 Effect of tillage methods and cultivars on 100 seed weight

Treatments	**100 seed weight**
Tillage methods (M)	
M_1 -Minimum tillage	3.68
M_2 -Minimum tillage *fb* pendimethalin	3.67
M_3 -Minimum tillage *fb* imazethapyr + imazamox	3.62
M_4 -Conventional tillage + two hand weedings	3.67
SEm (±)	0.05
CD (0.05)	NS
Cultivars (V)	
V_1 -CO 6	3.54
V_2 -CO 7	3.70
V_3 -CO 8	3.75
V_4 -VBN (Gg)2	3.66
SEm (±)	0.04
CD (0.05)	0.11

Table 4.16 Effect of tillage methods and cultivars on seed yield of greengram, kg/ha.

Treatments	**Yield (kg/ha)**
Tillage methods (M)	
M_1 -Minimum tillage	370
M_2 -Minimum tillage *fb* pendimethalin	571
M_3 -Minimum tillage *fb* imazethapyr + imazamox	748
M_4 -Conventional tillage + two hand weedings	705
SEm (±)	28.03
CD (0.05)	98.90
Cultivars (V)	
V_1 -CO 6	492
V_2 -CO 7	522
V_3 -CO 8	736
V_4 -VBN (Gg)2	645
SEm (±)	18.84
CD (0.05)	55.31

Interaction

	M1	M2	M3	M4
V1	341	410	631	585
V2	367	526	629	567
V3	392	697	942	911
V4	380	650	791	757

SEm (±) 56.07

CD (0.05) 120.10

Table 4.17 Effect of tillage methods and cultivars on biological yield of greengram, kg/ha

Treatments	**Yield**
Tillage methods (M)	
M_1 -Minimum tillage	1792
M_2 -Minimum tillage *fb* pendimethalin	2510
M_3 -Minimum tillage *fb* imazethapyr + imazamox	3127
M_4 -Conventional tillage + two hand weedings	2828
SEm (±)	126.75
CD (0.05)	447.15
Cultivars (V)	
V_1 -CO 6	2308
V_2 -CO 7	2341
V_3 -CO 8	2902
V_4 -VBN (Gg)2	2707
SEm (±)	105.92
CD (0.05)	311.01

4.5 OBSERVATION ON WEEDS

4.5.1 Species wise weed count

Nineteen weed species were observed in experimental field (Table 4.16). The predominant weed species were broad leaved weeds. The important broad leaved weeds were *Melochia chorchorifolia, Heliotropium indicum, Grangea maderaspatana, Cleome viscosa*. Among grasses, the predominant species were *Oryza sativa, Echinochloa colona, Eleusine indica* and *Digitaria ciliaris*. *Cyperus iria* was the only sedge observed.

4.5.1.1 Grasses

At 30 DAS, grassy weed population was not influenced by the tillage methods and cultivars (Table 4.17). At flowering stage methods of tillage were found significant. The lowest grass population was recorded in conventional tillage (M_4) (1.70) and at par with minimum tillage *fb* imazethapyr + imazamox (M_3).These treatments were superior to minimum tillage (M_1) and minimum tillage *fb* pendimethalin (M_2).

4.5.1.2 Sedges

Weed population at 30 DAS and flowering stage revealed that there was no significant variation in population of sedges between the tillage methods and cultivars (Table 4.18). The interaction effect was also not significant.

4.5.1.3 Broad leaved weeds

Analyzed data on broad leaved weeds population at 30 DAS and flowering stage revealed that the broad leaved weed population varied significantly with tillage methods (Table 4.19). The lowest value of broad leaved weed population was recorded in conventional tillage (M_4) (1.85) and it was at par with minimum tillage *fb* imazethapyr + imazamox (M_3) and minimum tillage *fb* pendimethalin (M_2) and significantly superior to minimum tillage (M_1). The highest value was recorded in minimum tillage (M_1) (2.28). At flowering stage the lowest population was found in conventional tillage (M_4) and it was statistically at par with minimum tillage *fb* imazethapyr + imazamox (M_3). The highest population was recorded in minimum tillage (M_1) (3.27).

4.5.5 Total Weed density

At 30DAS, the total weed density was significantly influenced by the methods of tillage (Table 4.20). The weed density (2.45 m^{-2}) was lower in conventional tillage method (M_4) and it was at par with minimum tillage *fb* pendimethalin (M_2) and minimum tillage *fb* imazethapyr + imazamox (M_3). Weed density (3.18 m^{-2}) was the highest in minimum tillage method (M_1).

At flowering stage, the lowest weed density (2.48 m^{-2}) was observed in conventional tillage method *fb* hand weedings (M_4) and found superior to the other methods of tillage. The treatments minimum tillage *fb* herbicide sprays were found statistically at par. The highest weed density (2.48 m^{-2}) was observed in minimum tillage (M_1).

The results revealed that the effect of cultivars on weed density were not significant during the growth stages.

The interaction effects were not significant.

4.5.6 Weed dry weight

The analyzed data revealed that weed dry weight varied with tillage methods (Table 4.21). At 30 DAS, the highest weed dry weight (11.58 g m^{-2}) was observed in minimum tillage method (M_1). The lowest dry weight (2.58 g m^{-2}) was observed in conventional tillage (M_4) followed by minimum tillage *fb* imazethapyr + imazamox (M_3). A similar trend was observed at flowering stage also. Between cultivars the

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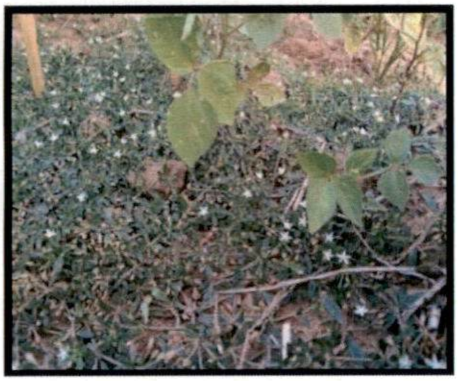
Melochia chorchorifolia

Heliotropium indicum



Oldenlandia umbellata

Grangea maderaspatana

Plate 8. Major broadleaved weeds

Phyllanthus sp.

Ludwigia parviflora

Spilanthus calva

Cleome viscosa

Plate 9. Major broad leaved weeds

Eleusine indica

Echinochloa colona

Digitaria ciliaris

Cyperus iria

Plate 10. Major grasses and sedge

variation in the weed dry weight were found to be statistically not significant at both stages. The interaction effects of tillage and cultivar were found to be statistically not significant at both stages. The lowest weed dry weight was observed in the treatment combination of M_4V_4 at 30DAS and at flowering.

Table 4.18 Weeds present in the field during experiment

Grasses	**Sedges**	**Broad leaved weeds**
Echinochloa colona	*Cyperus iria*	*Melochia chorchorifolia*
Digitaria ciliaris		*Heliotropium indicum*
Oryza sativa		*Grangea maderaspatana*
Eleusine indica		*Ludwigia parviflora*
Axonopus compressus		*Spilanthus calva*
		Cleome viscosa
		Oldenlandia umbellata
		Phyllanthus sp.
		Cyanthillium cinereum
		Eclipta alba
		Mollugo disticha
		Synedrella nodiflora
		Amaranthus viridis

Table 4.19 Effect of tillage methods and cultivars on number of grassy weeds

Treatments	**Number of grasses at 30 DAS (No. m^{-2})**	**Number of grasses at flowering (No. m^{-2})**
Tillage methods (M)		
M_1 -Minimum tillage	2.33 (4.46)	2.79 (7.08)
M_2 -Minimum tillage *fb* pendimethalin	2.06 (3.33)	2.57 (5.92)
M_3 -Minimum tillage *fb* imazethapyr + imazamox	1.81 (2.42)	2.13 (3.75)
M_4 -Conventional tillage + two hand weedings	1.81 (2.33)	1.70 (2.00)
SEm (±)	0.12	0.20
CD (0.05)	NS	0.71
Cultivars (V)		
V_1 -CO 6	1.98 (3.00)	2.37 (5.25)
V_2 -CO 7	2.01 (3.25)	2.25 (4.42)
V_3 -CO 8	2.16 (3.92)	2.36 (4.92)
V_4 -VBN (Gg)2	1.86 (2.58)	2.21 (4.17)
SEm (±)	0.08	0.13
CD (0.05)	NS	NS

Original values are given in parenthesis, which were transformed to $\sqrt{x+1}$

Table 4.20 Effect of tillage methods and cultivars on number of sedges

Treatments	**Number of sedges at 30 DAS (No. m^{-2})**	**Number of sedges at flowering (No. m^{-2})**
Tillage methods (M)		
M_1 -Minimum tillage	1.01 (0.42)	1.26 (0.83)
M_2 -Minimum tillage *fb* pendimethalin	1.07 (0.17)	1.14 (0.42)
M_3 -Minimum tillage *fb* imazethapyr + imazamox	1.07 (0.17)	1.07 (0.17)
M_4 -Conventional tillage + two hand weedings	1.10 (0.25)	1.00 (0.00)
SEm (±)	0.05	0.13
CD (0.05)	NS	NS
Cultivars (V)		
V_1 -CO 6	1.10 (0.25)	1.18 (0.58)
V_2 -CO 7	1.10 (0.25)	1.10 (0.25)
V_3 -CO 8	1.13 (0.33)	1.08 (0.25)
V_4 -VBN (Gg)2	1.07 (0.17)	1.12 (0.33)
SEm (±)	0.07	0.08
CD (0.05)	NS	NS

Original values are given in parenthesis, which were transformed to $\sqrt{x+1}$

Table 4.21 Effect of tillage methods and cultivars on number of broadleaved weeds

Treatments	**Number of broad leaved weeds at 30 DAS (No. m^{-2})**	**Number of broad leaved weeds at flowering (No. m^{-2})**
Tillage methods (M)		
M_1 -Minimum tillage	2.28 (4.33)	3.27 (10.17)
M_2 -Minimum tillage *fb* pendimethalin	1.88 (2.67)	2.54 (5.83)
M_3 -Minimum tillage *fb* imazethapyr + imazamox	1.87 (2.58)	2.44 (5.42)
M_4 -Conventional tillage + two hand weedings	1.85 (2.50)	2.02 (3.25)
SEm (±)	0.05	0.12
CD (0.05)	0.17	0.44
Cultivars (V)		
V_1 -CO 6	2.06 (3.33)	2.69 (6.75)
V_2 -CO 7	2.02 (3.25)	2.48 (5.50)
V_3 -CO 8	1.98 (3.08)	2.50 (5.83)
V_4 -VBN (Gg)2	1.82 (2.42)	2.60 (6.58)
SEm (±)	0.10	0.15
CD (0.05)	NS	NS

Original values are given in parenthesis, which were transformed to $\sqrt{x+1}$

Table 4.22 Effect of tillage methods and cultivars on total weed density (No. m^{-2})

Treatments	**Total number of weeds at 30 DAS**	**Total number of weeds at flowering**
Tillage methods (M)		
M_1 -Minimum tillage	3.18	4.33
M_2 -Minimum tillage *fb* pendimethalin	2.66	3.57
M_3 -Minimum tillage *fb* imazethapyr + imazamox	2.47	3.16
M_4 -Conventional tillage + two hand weedings	2.45	2.48
SEm (±)	0.11	0.19
CD (0.05)	0.37	0.69
Cultivars (V)		
V_1 -CO 6	2.74	3.55
V_2 -CO 7	2.73	3.27
V_3 -CO 8	2.82	3.35
V_4 -VBN (Gg)2	2.46	3.37
SEm (±)	0.09	0.15
CD (0.05)	NS	NS

Table 4.23 Effect of tillage methods and cultivars on weed dry weight (g m^{-2})

Treatments	Dry weight of weeds at 30 DAS (g m^{-2})	Dry weight of weeds at flowering (g m^{-2})
Tillage methods (M)		
M_1 -Minimum tillage	11.58	47.50
M_2 -Minimum tillage *fb* pendimethalin	7.25	20.50
M_3 -Minimum tillage *fb* imazethapyr + imazamox	4.92	9.92
M_4 -Conventional tillage + two hand weedings	2.58	3.67
SEm (±)	0.41	1.51
CD (0.05)	1.45	5.33
Cultivars (V)		
V_1 -CO 6	6.17	21.33
V_2 -CO 7	6.58	20.75
V_3 -CO 8	6.67	19.92
V_4 -VBN (Gg)2	6.98	19.58
SEm (±)	0.42	1.72
CD (0.05)	NS	NS

4.6 SOIL ANALYSIS

The analyzed data are presented in Table 4.22

4.6.1 Organic Carbon Content of Soil

The methods of tillage had a significant effect on soil organic carbon status. The minimum tillage (M_1) and minimum tillage *fb* imazethapyr + imazamox (M_3) recorded more soil organic carbon status than minimum tillage *fb* pendimethalin (M_2) and conventional tillage (M_4). Minimum tillage (M_1) recorded higher organic carbon (1.13%) which was at par with minimum tillage *fb* imazethapyr + imazamox (M_3) (1.10%) and found significantly superior to minimum tillage *fb* pendimethalin (M_2) and conventional tillage (M_4). Conventional tillage (M_4) recorded lower organic carbon (1.02%) which was at par with minimum tillage *fb* pendimethalin (M_2).The influence of cultivars was found not significant during the experiment. All interaction were found not significant.

4.6.2 Nitrogen Content of Soil

The influence of tillage methods on soil nitrogen was found significant (Table 4.22). The minimum tillage (M_1) recorded more soil nitrogen (138.47 kg ha^{-1}) and was found on par with minimum tillage *fb* pendimethalin (M_2) & minimum tillage *fb* imazethapyr + imazamox (M_3). The soil nitrogen was the lowest (116.02kg ha^{-1}) in conventional tillage (M_4) and was significantly inferior to minimum tillage treatments. The results revealed that the soil nitrogen was not influenced by the cultivars. The interaction effects were found not significant.

4.6.3 Phosphorous Content of Soil

The results revealed that soil P was significantly influenced by tillage methods. Minimum tillage recorded the highest soil P (16.66 kg ha^{-1}) and found significantly superior to all other treatments .The cultivars did not affect the soil P. All the interaction were found not significant.

4.6.4 Potassium Content of Soil

The methods of tillage significantly influenced the soil K status. Among the tillage methods minimum tillage (M_1) recorded the highest K value of 180.29 kg ha^{-1}. The lowest K was found in conventional tillage (M_4) which was significantly inferior to the other 3 minimum tillage treatments. The cultivars and the interaction effects fail to produce any significant effect on soil K status.

4.7 NUTRIENT UPTAKE AT HARVEST

The uptake of nutrients was significantly influenced by the methods of tillage (Table 4.23). The higher nitrogen uptake (42.05 kg ha^{-1}) was recorded in minimum tillage *fb* imazethapyr + imazamox (M_3) which was at par with conventional tillage (M_4). The lower uptake (28.70 kg ha^{-1}) was recorded in minimum tillage (M_1) method and which was at par with minimum tillage *fb* pendimethalin (M_2). There was no significant difference between the four cultivars in uptake of nutrients. The interaction effect was also found not significant.

The higher uptake of P (9.26 kg ha^{-1}) was also recorded by minimum tillage *fb* imazethapyr + imazamox (M_3) and was at par with conventional tillage (M_4). The effect of cultivars on P uptake was not significant. The lower P uptake (5.84 kg ha^{-1}) was recorded by minimum tillage (M_1) which was at par with minimum tillage *fb* pendimethalin (M_2). The P uptake was not influenced by the cultivars. The interaction effects also found not significant.

The methods of tillage and cultivars significantly influenced by the total K uptake. Conventional tillage (M_4) and minimum tillage *fb* imazethapyr + imazamox (M_3) (22.83 and 20.89, respectively) recorded the higher uptake. The K uptake (15.98 kg ha^{-1}) by the minimum tillage method (M_1) was found significantly inferior to all other methods. The cultivar CO 8 (V_3) recorded the higher uptake and was found at par with CO 7 (V_2). The lowest uptake was recorded by CO 6 (V_1) and was at par with CO 7 (V_2) and VBN (Gg)2 (V_4). The interaction effects were also found not significant.

4.8 ECONOMICS OF CULTIVATION

The results are presented in Table 4.24.

The cost of cultivation varied with methods of tillage. The minimum tillage recorded the lowest cost of cultivation (Rs. 38694). The highest cost of cultivation was recorded in conventional tillage followed by hand weeding (Rs.52494). The cost of cultivation of minimum tillage *fb* pendimethalin(M_2) and minimum tillage *fb* imazethapyr + imazamox (M_3) were Rs. 41348 and Rs. 41690, respectively.

The highest gross income was obtained from minimum tillage *fb* imazethapyr + imazamox (M_3) (Rs.63608) followed by conventional tillage (M_4) (Rs. 59925). The lowest income (Rs. 31437) was obtained from the minimum tillage (M_1) which recorded the lowest BCR of 0.81. The highest BCR was realized from minimum tillage *fb* imazethapyr + imazamox (M_3) (1.53) followed by minimum tillage *fb* pendimethalin (M_2) (1.17) and conventional tillage (M_4) (1.14).

Among the treatment combinations, economic analysis revealed that cultivar CO 8 (V3) grown under minimum tillage followed by imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_3V_3) recorded the highest gross returns (Rs.80106) and benefit cost ratio (1.92). All cultivars in minimum tillage, cultivar CO 6 (V_1) and CO 7 (V_2) grown under conventional tillage and CO 6 (V_1) grown under minimum tillage followed by pre-emergence application of pendimethalin recorded benefit cost ratio of less than 1.

Table 4.24 Effect of tillage methods and cultivars on soil organic carbon, N, P, and K at harvest

Treatments	Organic carbon (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
Tillage methods (M)				
M_1 -Minimum tillage	1.13	138.47	16.66	180.29
M_2 -Minimum tillage *fb* pendimethalin	1.04	128.10	14.24	148.52
M_3 -Minimum tillage *fb* imazethapyr + imazamox	1.10	129.67	13.66	151.16
M_4 -Conventional tillage + two hand weedings	1.02	116.02	13.21	132.64
SEm (±)	0.01	3.12	0.60	4.50
CD (0.05)	0.04	11.00	2.13	15.90
Cultivars (V)				
V_1 -CO 6	1.05	126.40	14.48	156.94
V_2 -CO 7	1.08	128.62	14.94	153.49
V_3 -CO 8	1.09	127.05	13.72	154.14
V_4 -VBN (Gg)2	1.07	130.20	14.63	148.03
SEm (±)	0.01	3.48	0.50	8.70
CD (0.05)	NS	NS	NS	NS

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Table 4.25 Effect of tillage methods and cultivars on nutrient uptake by greengram at harvest

Treatments	**Nitrogen (kg/ha)**	**Phosphorus (kg/ha)**	**Potassium (kg/ha)**
Tillage methods (M)			
M_1 -Minimum tillage	28.70	5.84	15.98
M_2 -Minimum tillage *fb* pendimethalin	32.31	6.74	18.13
M_3 -Minimum tillage *fb* imazethapyr + imazamox	42.05	9.26	20.89
M_4 -Conventional tillage + two hand weedings	39.32	7.83	22.83
SEm (±)	1.71	0.50	0.80
CD (0.05)	6.03	1.76	2.82
Cultivars (V)			
V_1 -CO 6	34.52	7.22	17.90
V_2 -CO 7	33.71	6.44	19.52
V_3 -CO 8	37.08	8.51	21.87
V_4 -VBN (Gg)2	37.07	7.49	18.53
SEm (±)	1.29	0.51	1.00
CD (0.05)	NS	NS	2.94

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Table 4.26 Economics of greengram cultivation

Treatments	**Cost of cultivation/ha (Rs)**	**Gross returns/ha (Rs)**	**B : C ratio**
M_1 -Minimum tillage	38694	31437	0.81
M_2 -Minimum tillage *fb* pendimethalin	41348	48527	1.17
M_3 -Minimum tillage *fb* imazethapyr + imazamox	41690	63608	1.53
M_4 -Conventional tillage + two hand weedings	52494	59925	1.14

Interaction

Treatments	Gross returns/ha (Rs.)	B : C ratio
M1V1	28952	0.75
M1V2	31167	0.81
M1V3	33330	0.86
M1V4	32300	0.83
M2V1	34876	0.84
M2V2	44715	1.08
M2V3	59242	1.43
M2V4	55276	1.34
M3V1	53627	1.29
M3V2	53473	1.28
M3V3	80106	1.92
M3V4	67227	1.61
M4V1	49764	0.95
M4V2	48167	0.92
M4V3	77427	1.47
M4V4	64342	1.23

DISCUSSION

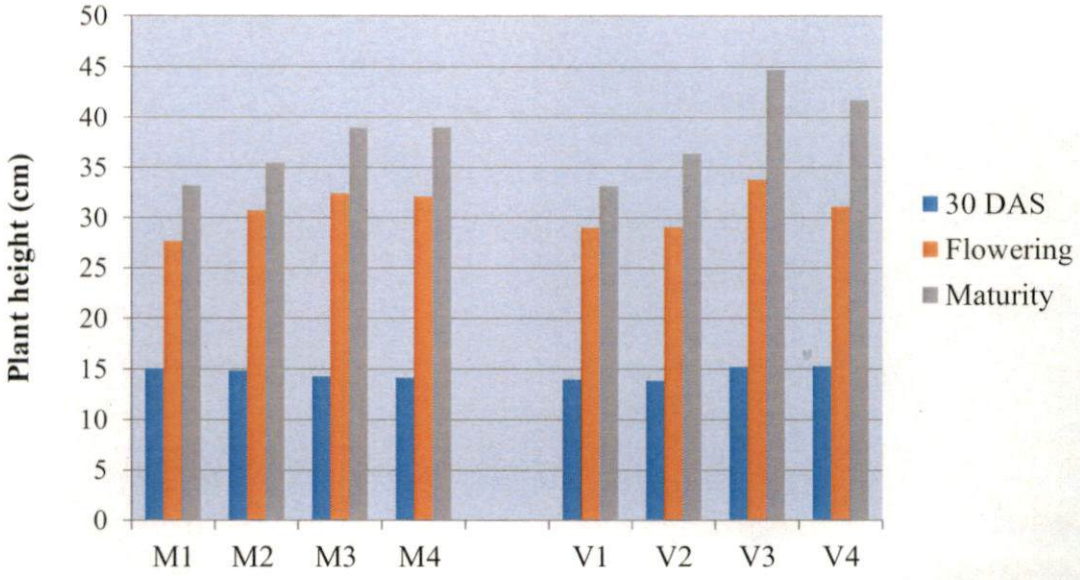
5. DISCUSSION

An experiment entitled "Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods" was undertaken with the objectives to study the response of selected greengram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage. The results of the experiment presented in the previous chapter are discussed below.

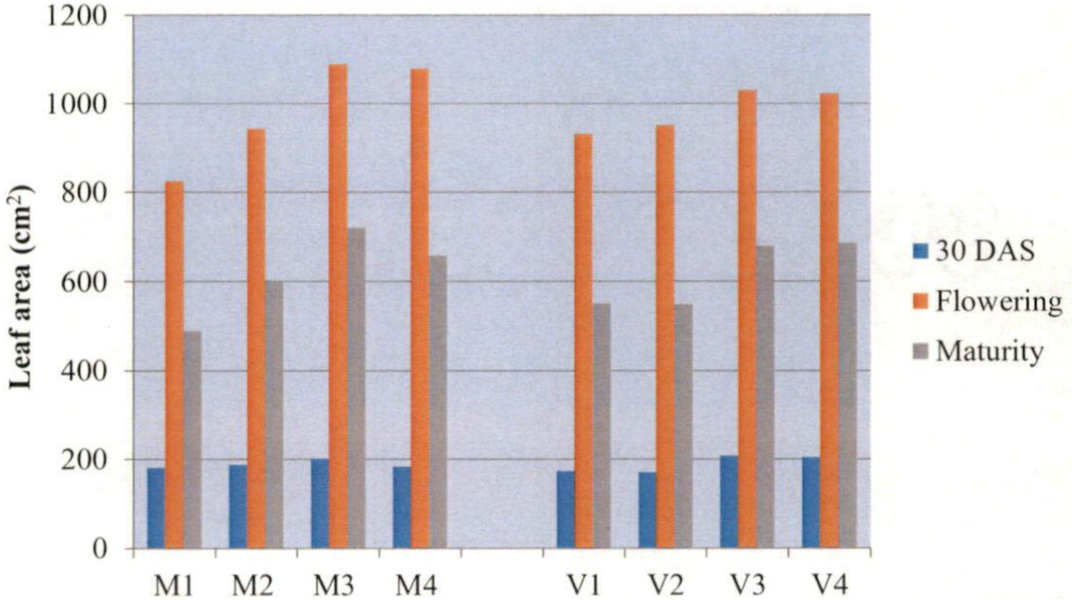
5.1. EFFECT OF TILLAGE METHODS ON GROWTH, YIELD AND QUALITY OF GREENGRAM

The results on growth and yield attributes of greengram revealed the influence of tillage methods on its productivity. The minimum tillage method provided the best alternative to the conventional tillage, due to their conservation effects on the soil and to crop yield increased as compared to the conventional method.

Plant height, numbers of branches and leaf area varied significantly with tillage methods at flowering and at harvest stages but not during vegetative growth phase (Fig.3). The taller plants were observed in minimum tillage followed by application of herbicide imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and conventional tillage followed by two hand weedings at 15 and 30 DAS. This was mainly due to weed free situation which is evident from data on weed dry matter production. The shortest plants were observed in minimum tillage due to the severe crop weed competition. Branching is basically a genetic character but environmental conditions may also influence the number of branches per plant and play an important role in enhancing seed yield. The number of branches was higher in minimum tillage followed by herbicide treatments due to the less crop weed competition. The higher leaf area in minimum tillage followed by application of herbicide imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and conventional tillage followed by two hand weedings at 15 and 30 DAS were due



a. Plant height of greengram as influenced by methods of tillage and cultivars



b. Leaf area of greengram as influenced by methods of tillage and cultivars

Fig.3 Growth attributes of greengram as influenced by methods of tillage and cultivars

M_1- Minimum tillage
M_2- Minimum tillage *fb* pendimethalin
M_3- Minimum tillage *fb* imazethapyr + imazamox
M_4- Conventional tillage + two hand weedings

V_1 -CO 6
V_2 -CO 7
V_3 -CO 8
V_4 -VBN (Gg)2

to more vigorous growth of plants. These treatments had higher values of crop dry matter production and plant nutrients uptake.

The physiological parameters *viz.,* CGR, LAI, LAD and number of nodules were affected by tillage methods (Fig.4). The leaf area index (LAI) increased with crop growth up to flowering after which it declined. This was attributed to leaf fall and concurred with earlier findings of Kumar (2000) who noted that LAI, plant height and functional canopy initially increased with time of growth then decreased due to leaf senescence. Flowering is governed by the phenology of particular cultivar, than physical factors like tillage and cultivation practices. In the present study, 50 per cent flowering was not influenced by the tillage methods. It is obvious from the results that the number of nodules increased up to flowering stage and thereafter declined at maturity. The results revealed that minimum tillage *fb* pendimethalin (M_2), minimum tillage *fb* imazethapyr + imazamox (M_3) and conventional tillage (M_4) were at par and superior to minimum tillage (M_1) at 30 DAS due to better growth attributes. In conventional tillage, number of nodules increased due to better aeration caused by hand weedings.

The yield attributes *viz.,* number of pods per plant, number of seeds per pod and100 seed weight varied significantly with tillage methods (Fig.5). Minimum tillage followed by application of herbicide imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS recorded higher number of pods, number of seeds per pod and 100 seed weight and was on a par with conventional tillage followed by two hand weedings at 15 and 30 DAS. This may be due to favourable soil moisture condition in minimum tillage plots along with lesser weed competition due to post emergence herbicide application resulted in higher productivity. Similarly conventional tillage treatments helped to develop a favourable environment for crop growth which resulted in better yield parameters. Conventional tillage had a positive impact on crop growth rate in comparison to no-tilled plots (Sangakkara, 2007).

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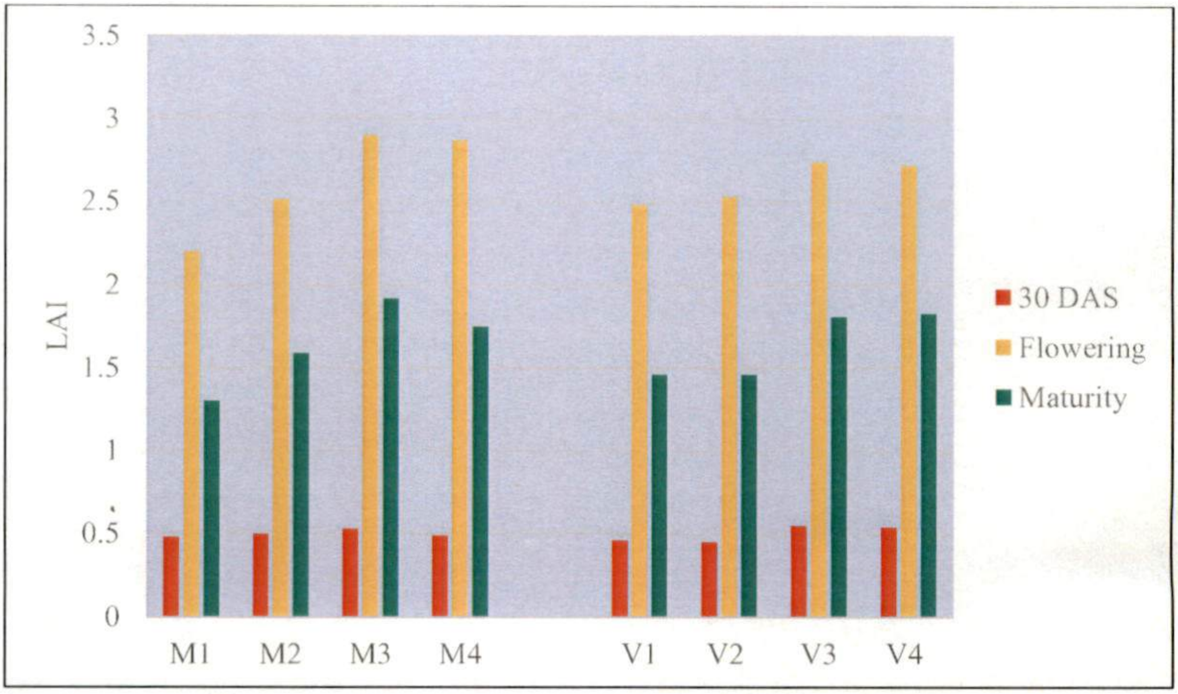

Fig.4 Leaf area index (LAI) of greegram as influenced by methods of tillage and cultivars

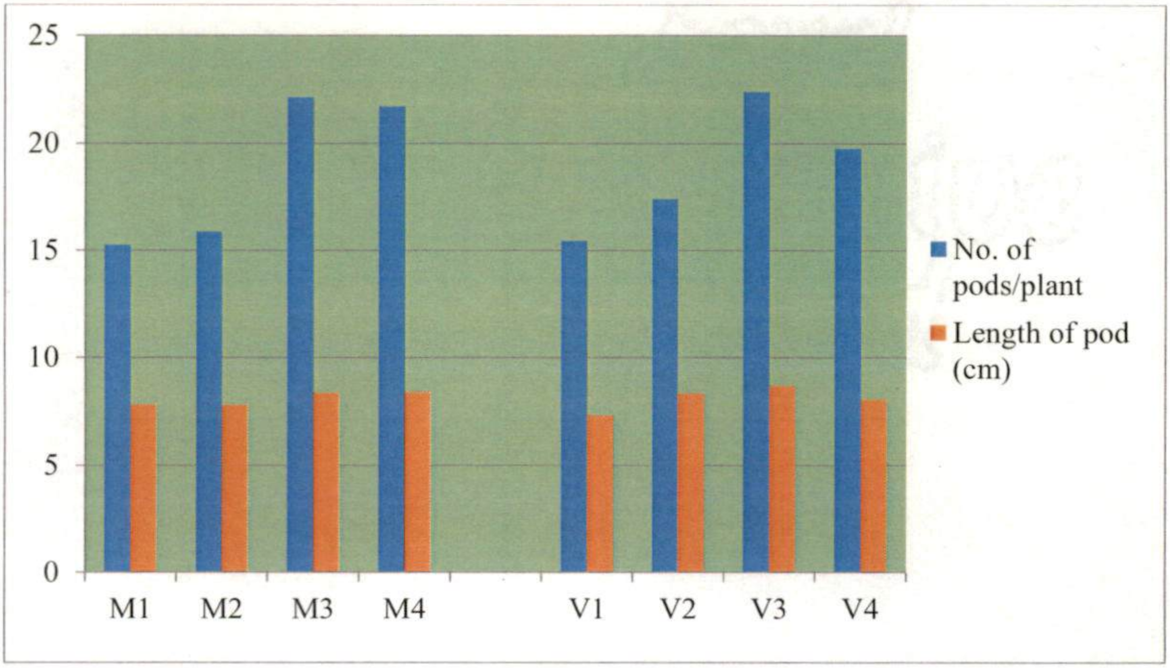

Fig.5 Yield attributes of greengram as influenced by methods of tillage and cultivars

M_1- Minimum tillage	V_1 -CO 6
M_2- Minimum tillage *fb* pendimethalin	V_2 -CO 7
M_3- Minimum tillage *fb* imazethapyr + imazamox	V_3 -CO 8
M_4- Conventional tillage + two hand weedings	V_4 -VBN (Gg)2

The results revealed that the tillage methods significantly influenced the seed yield. Minimum tillage followed by post emergence application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS recorded higher seed yield (748.33 kg ha^{-1}) and it was at par with conventional tillage followed by two hand weeding at 15 and 30 DAS and significantly superior to the other two methods of tillage. The minimum tillage recorded the lowest seed yield (369.85 kg ha^{-1}). Minimum tillage followed by imazethapyr + imazamox @80 g ha^{-1} at 20 DAS recorded 102 % higher seed yield than minimum tillage. The increase yield under minimum tillage followed by imazethapyr + imazamox @ 80g ha^{-1} at 20 DAS was mainly due to the increase in growth and yield attributes. This was in conformity with the findings of Kumar *et al*., (2014) in summer greengram. The harvest index was not significantly varied by tillage methods which was also reported by Banjara *et al.,* (2017).

The biological yield also followed the same trend of seed yield. It was the highest in minimum tillage followed by imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (3127.41 kg ha^{-1}) and was at par with conventional tillage followed by hand weedings. The lowest biological yield (1792.59 kg ha^{-1}) was recorded in the minimum tillage which in turn resulted in lower seed yield and dry matter production.

The protein content did not vary with methods of tillage.

5.2. DIFFERENTIAL RESPONSE OF CULTIVARS ON GROWTH, YIELD AND QUALITY OF GREENGRAM

The significant variations in plant height among the varieties may be due to their genetic variability for this trait. Mahalakshmi *et al.* (2002), Reddy *et al.* (2003), Ghosh *et al.(*2006), Gosami *et al.* (2009), Goswami *et al.* (2010) and Shakya (2016) have also reported varietal variation with respect to plant height in greengram. Branching is an important character of pulses which is directly related with the number of pods per plant and ultimately the yield of crop. In the present study, the cultivars

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viz., CO 8 and VBN (Gg)2 had higher values for all the growth parameters as compared to CO 6 and CO 7. Greengram leaves are tri-foliate with overlapping horizontal orientation that tends to limit light distribution into the canopy. Greengram cultivar with narrower leaves and higher light interception was found to have a higher yield potential compared to a greengram with broader leaves (Lee *et al*., 2014). In this experiment the cultivar CO 8 had narrower leaves which might have contributed to higher yield compared to other three cultivars.

The growth analysis indicated that in all the cultivars the CGR values increased up to 30-44 days after sowing (DAS) and thereafter declined till maturity. The values for RGR showed a decreasing trend as crop advanced in age. LAI values followed an increasing trend up to 45 DAS due to peak vegetative growth at this stage and thereafter started declining. In all the cultivars, NAR showed a decreasing trend till the crop reached the harvesting stage. LAI of cultivars CO 8 (V3) and VBN (Gg) 2 (V4) were at par and superior to CO 6 (V1) and Co 7 (V2). The cultivar CO 8 (V3) recorded the higher LAD at all growth stages which is a better reason for high yield potential of this cultivar. The critical leaf area index was 3 to 4 which can enable a crop to intercept over 90 per cent of the incidence radiation during pod filling stage (Muchow, 1985). All the cultivars showed a decreasing trend in RGR as crop advanced in age during the season but CGR increased up to 60 DAS and thereafter declined gradually. The decrease in RGR is due to the decrease in NAR. A similar decline in RGR due to decrease in NAR was reported by Wallace and Munger (1965) in peas and Pandey *et al.* (1978) in blackgram.

Higher values of yield components *viz*., number of pods per plant, number of seeds per pod, 100 seed weight and harvest index were recorded in CO 8 followed by VBN (Gg)2. The higher values of LAI resulted due to better branching which resulted in higher leaf area in cultivar CO 8.

Productivity in greengram depends on the crop's ability to produce and partition dry matter to yield. This follows a series of development stages in the plant. During these stages, the plant develops a leaf canopy, intercepts solar radiation, converts the absorbed radiation into assimilates and partitions these assimilates into various plant components including roots, pods and seeds. Variations in yield attributing parameters among the different cultivars obtained from the different parental origin are common. Higher or lower yield attributing characters among the different cultivars are the genetically controlled phenomenon. The cultivar CO 8 recorded the highest seed yield (735.61 kg ha^{-1}) and superior to other three cultivars. It was followed by VBN (Gg) 2 with a seed yield of 644.55 kg ha^{-1}. The cultivars CO 6 and CO 7 were at par with a seed yield of 491.82 kg ha^{-1} and 522.12 kg ha^{-1}. The higher seed yield in CO 8 was due to higher growth and yield attributes.

Harvest index is a measure of physiological productivity of a crop cultivar. It is the ability of a crop to convert the dry matter into economic yield. It is the ratio of seed yield to biological yield and those varieties with more seed yield would have higher harvest index value. The comparable values of harvest index indicated that cultivars did not differ significantly in conversion efficiency of assimilates.

The data pertaining to the number of nodules per plant at flowering showed that the cultivars differed significantly from each other in nodulation process. The higher number of nodules (19.40) were observed in CO 8 which was at par with VBN (Gg)2 and lower number of nodules (17.05) were produced by the cultivar CO 6 which was statistically at par with CO 7. This difference might be due to genetic variability of the cultivars.

5.3. INTERACTIVE EFFECT OF TILLAGE METHODS AND CULTIVARS ON PRODUCTIVITY OF GREENGRAM

The combined effect of cultivars and methods of tillage on yield was found to be significant. The interaction effects is depicted in Fig. 6. The cultivar CO 8 in minimum tillage followed by imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_3V_3) recorded the higher seed yield (942.42 kg ha^{-1}) and it was at par with conventional tillage followed by hand weeding treatments(M_4V_3). The lower seed yield (340.61 kg ha^{-1}) was recorded with the treatment combination of minimum tillage with CO 6 (M_1V_1) and it was at par with minimum tillage with other three cultivars (M_1V_2, M_1V_3 and M_1V_4) and minimum tillage + pendimethalin @ 1kg ha^{-1} with CO 6 (M_2V_1). This was due to the differential response of greengram cultivars under different tillage methods. Imran *et al.* (2016) also reported that plant height, yield and yield attributes and protein content of greengram were significantly affected by cultivars and tillage systems.

5.4. TILLAGE METHODS AND CULTIVARS ON WEEDS

Crop rotation, tillage methods, application of agrochemicals and agricultural practices influence the weed seed bank and weed flora (Marshall *et al.,* 2003). Manipulation of cropping systems as a component of integrated weed management requires a good understanding of weed dynamics and influence of crop and soil-related factors on weed life cycles (Davis *et al.,* 2003).

In an integrated approach, the development of cropping systems with efficient tillage methods will help crops to compete with weeds. Nineteen weed species were observed in experimental field. The predominant were broad leaved weeds. The percentage distributions of weeds are illustrated in Fig.7. The weed density and dry weight were lower under minimum tillage treatments followed by herbicide treatments and conventional tillage followed by hand weedings (Fig. 8). These treatments reduced the crop weed competition which had favoured crop growth and provided higher grain and stover yield. At flowering stage, the lowest grass population was recorded in conventional tillage followed by hand weeding. Weed population at 30 DAS and at flowering stage revealed that there was no significant variation in population of sedges.

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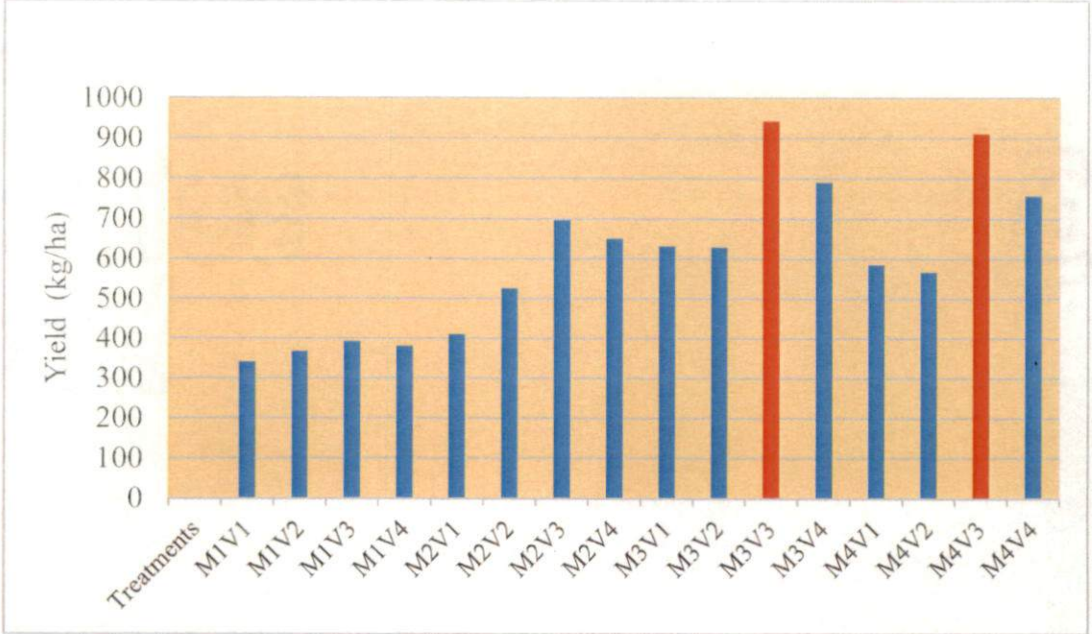

Fig.6 Seed yield of greengram as influenced by methods of tillage and cultivars

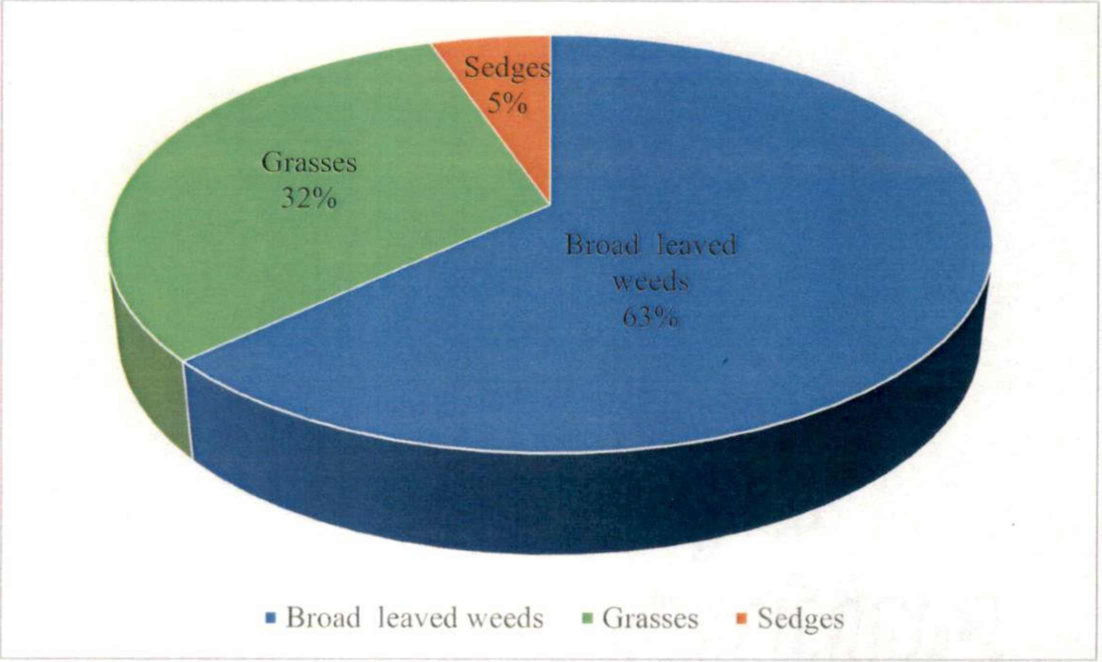

Fig.7 Species wise distribution of weeds in experimental field

M_1- Minimum tillage
M_2- Minimum tillage *fb* pendimethalin
M_3- Minimum tillage *fb* imazethapyr + imazamox
M_4- Conventional tillage + two hand weedings

V_1 -CO 6
V_2 -CO 7
V_3 -CO 8
V_4 -VBN (Gg)2

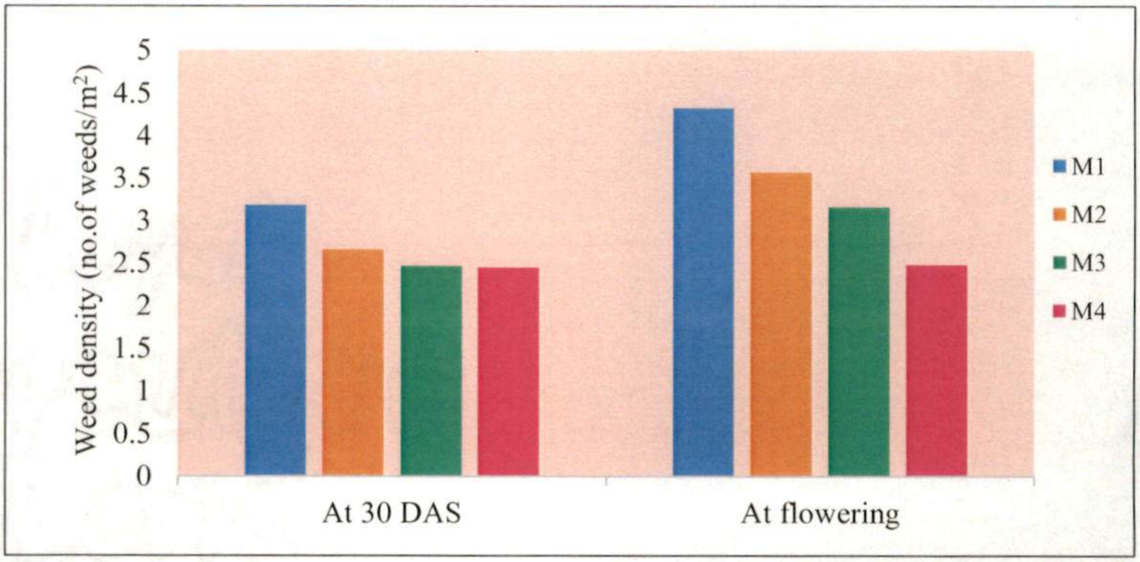

Fig.8 Weed density as influenced by methods of tillage

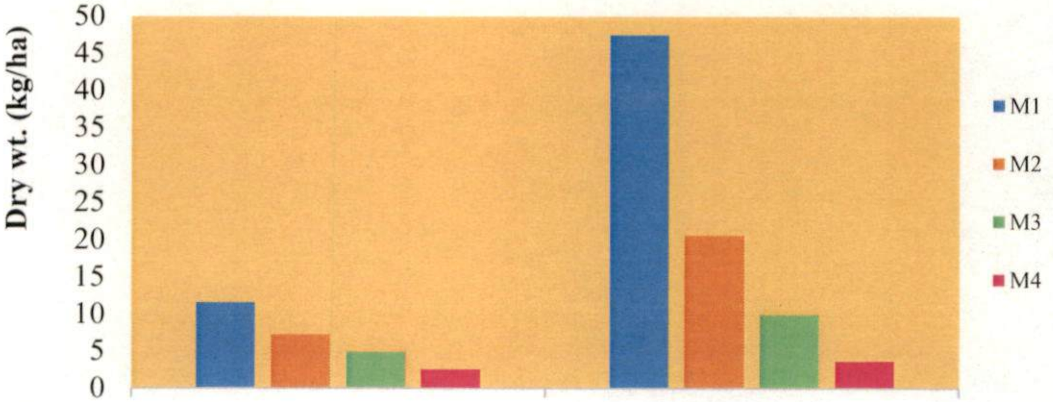

Fig.9 Weed dry weight as influenced by methods of tillage

M_1- Minimum tillage	V_1 -CO 6
M_2- Minimum tillage *fb* pendimethalin	V_2 -CO 7
M_3- Minimum tillage *fb* imazethapyr + imazamox	V_3 -CO 8
M_4- Conventional tillage + two hand weedings	V_4 -VBN (Gg)2

This may be due to their lower population density. Weed density of broad leaved population at 30 DAS and flowering stage revealed that the broad leaved weed population varied significantly with tillage methods. The lowest value of broad leaved weed population was recorded in conventional tillage followed by hand weedings. It was at par with the minimum tillage followed by herbicide treatments. The herbicides pendimethalin or imazethapyr + imazamox were equally effective in reducing the weed density of broad leaved weeds at 30 DAS.

Weed competition is considered as one of the most important causes of low productivity. The lowest yield in the minimum tillage may be due to the highest weed dry weight and weed density. Enhanced growth and yield attributes in post-emergence application of imazethapyr + imazamox led to less crop and weed competition and higher seed yield of greengram. This was in conformity with the findings of Kumar *et al.* (2016).

5.5. EFFECT OF TILLAGE METHODS AND CULTIVARS ON SOIL FERTILITY AND UPTAKE OF NUTRIENTS

By adopting conservation tillage practices, pulses can be introduced in to cereal based crop rotation. Studies have demonstrated that the nitrogen fixation benefits of conservation tillage and improvement in soil fertility of the system (Van Kessel and Hartley, 2000). Bindhu *et al.,* (2014) reported the positive buildup of nitrogen through sustainable crop intensification with greengram and black gram in summer fallows. Tillage methods affects the nutrient availability in the soil by modifying soil physical properties such as aggregate size, porosity, moisture content and bulk density (Chandra *et al*., 2017). The results clearly indicated that the method of tillages had significant influence on soil fertility status (Fig.10). In the present study, minimum tillage method had 11 per cent more organic carbon content than conventional tillage system. The

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increased organic carbon content under minimum tillage may be due to more crop residues left on soil surface which led to accumulation of organic carbon in soil.

Conventional tillage leaves soil vulnerable to water and wind erosion, increases agricultural runoff, degrades soil productivity and releases greenhouse gases both from soil disturbance and fossil fuel use. No-till or direct seeding under a mulch layer from the previous crop, reverses this process by implementing a package of practices, which includes minimum mechanical soil disturbance, permanent organic soil cover and diversification of crop species grown in sequences or association (FAO, 2013). Among the tillage methods, the best treatment with respect to available nitrogen, phosphorus and potassium after the experiment was minimum tillage when compared to conventional tillage. The percentage increase of available nitrogen, phosphorus and potassium in minimum tillage over conventional tillage were 19, 26 and 36 per cent, respectively. Similar results were also reported by Yadav *et al.* (2015) and Samant and Patra (2016).

The plant uptake is a function of nutrient content and dry matter production of the plant (Fig.11). The higher values of nutrient content and dry matter production in minimum tillage followed by post emergence application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and conventional tillage with hand weeded treatments resulted in increased uptake values. This may be due to the lower weed density and weed dry matter production in these treatments. Similarly the potassium uptake was significantly influenced by the cultivars. The cultivars CO 8, CO 7 and VBN (Gg) 2 recorded higher uptake values than minimum tillage treatment. The superiority of cultivars due to better productivity resulted in higher uptake values.

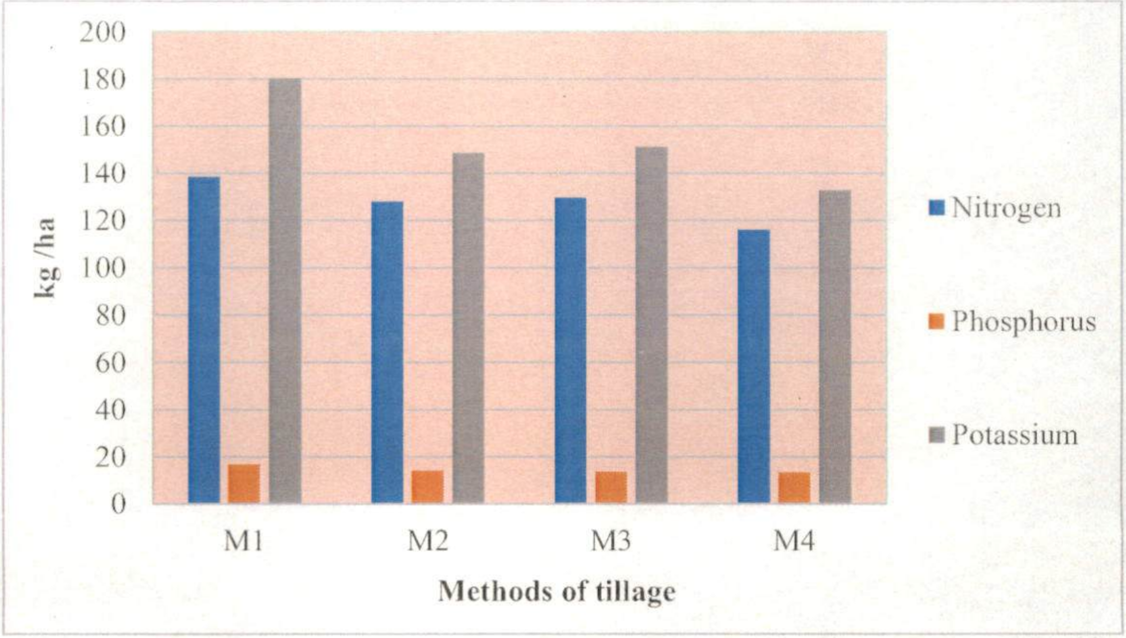

Fig.10 Soil nutrient status after the experiment as influenced by methods of tillage

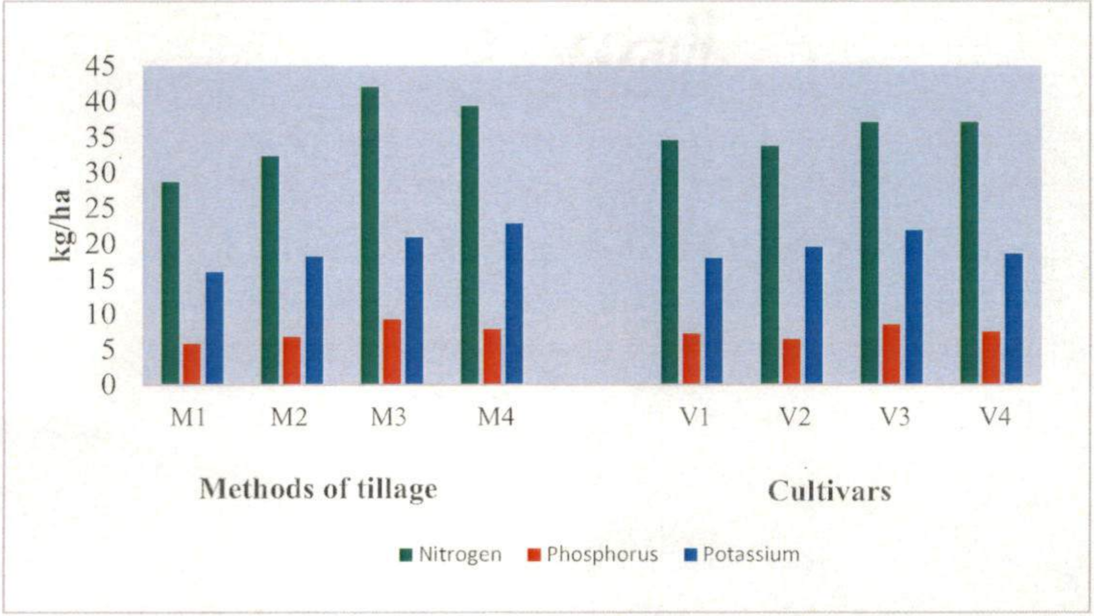

Fig. 11 N, P and K uptake at harvest as influenced by methods of tillage and cultivars

M_1- Minimum tillage	V_1 -CO 6
M_2- Minimum tillage *fb* pendimethalin	V_2 -CO 7
M_3- Minimum tillage *fb* imazethapyr + imazamox	V_3 -CO 8
M_4- Conventional tillage + two hand weedings	V_4 -VBN (Gg)2

5.6. ECONOMICS OF GREENGRAM CULTIVATION AS INFLUENCED BY TILLAGE METHODS AND CULTIVARS

Economic analysis also showed the same trend as that of seed yield of greengram (Fig.12 & 13). The cost of cultivation of greengram varied with the tillage methods. Correct choice of the tillage system for the crops in a rotation helped to reduce energy consumption (Rusu, 2014). The economic analysis of data revealed that less cost of cultivation from the minimum tillage plots due to less labour cost and compared to conventional tillage followed by hand weedings.

Cultivar CO 8 recorded higher gross and net returns due to high yield. The same cultivar had also recorded the highest benefit cost ratio due to its higher productivity which was followed by VBN (Gg)2 and CO 7. The cultivars CO 6 recorded the lowest net returns due to lower seed yield.

Minimum tillage followed by post emergence application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS was found to be a better option in terms of yield and net returns in green gram in summer rice fallows. The cultivar CO 8 was found to be the most promising one for the summer fallows and it can be a better option under both minimum and conventional tillage system.

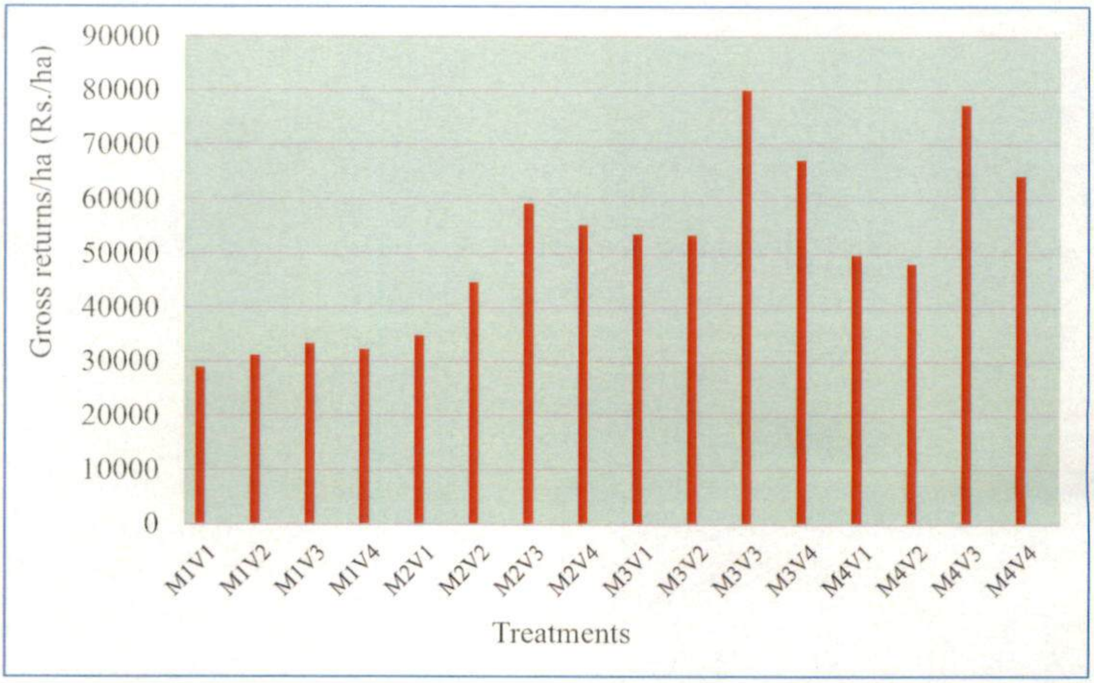

Fig.12 Gross returns as influenced by methods of tillage and cultivars

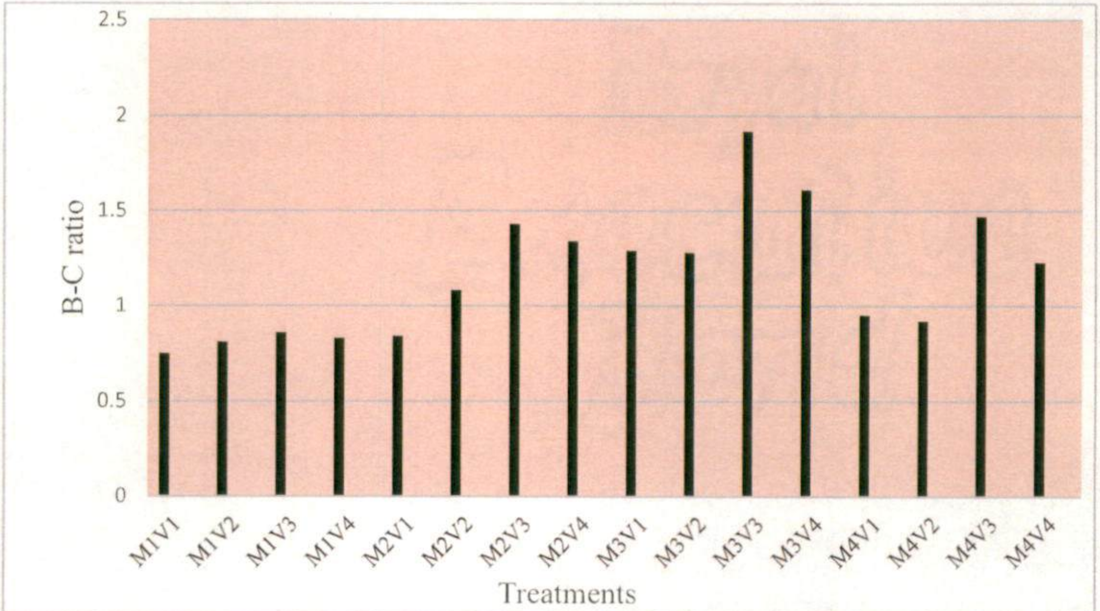

Fig.13 B-C ratio as influenced by methods of tillage and cultivars

M_1- Minimum tillage	V_1 -CO 6
M_2- Minimum tillage *fb* pendimethalin	V_2 -CO 7
M_3- Minimum tillage *fb* imazethapyr + imazamox	V_3 -CO 8
M_4- Conventional tillage + two hand weedings	V_4 -VBN (Gg)2

SUMMARY

6. SUMMARY

An investigation entitled "Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods" was undertaken with the objectives to assess the response of selected greengram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage. The experiment was conducted during the period from December 2017 to March 2018 at Agronomy Farm, College of Horticulture, Vellanikkara.

Split plot design was adopted with three replications. The main plot treatments were four tillage methods *viz.*, M_1 - minimum tillage (primary tillage only), M_2 - minimum tillage followed by pre-emergence application of pendimethalin @ 1 kg ha^{-1}, M_3 - Minimum tillage followed by post-emergence application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and M_4 - conventional tillage (Primary and secondary tillage) followed by two hand weedings at 15 and 30 DAS. Sub plot treatments were four cultivars; V_1 –CO 6, V_2–CO 7, V_3–CO 8 and V_4 -VBN (Gg) 2.

The results of the experiment are summarized below.

The growth attributes of greengram were recorded at 30 days after sowing (DAS), at flowering and at harvest. The growth attributes (plant height, number of branches and leaf area) at flowering and harvest stages were influenced by tillage methods. Higher values for growth parameters were observed in minimum tillage followed by application of herbicide imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_3) and the lowest in minimum tillage (M_1). Among the cultivars, Co 8 and VBN (Gg) 2 had recorded more growth parameters. At flowering and at harvest stages, the cultivar CO 8 was the tallest (33.87 cm and 44.74 cm, respectively) and was found superior to other three cultivars. There was no significant difference in the number of days taken for 50 per cent flowering with respect to tillage methods and cultivars.

The physiological parameters, CGR, LAI, LAD and number of nodules per plant also varied with tillage methods and cultivars. At all growth stages, CGR in minimum tillage *fb* imazethapyr + mazamox (M_3) and conventional tillage (M_4) were at par and found superior to minimum tillage (M_1) and minimum tillage *fb* pendimethalin (M_2). The cultivar CO 8 (V_3) and VBN (Gg)2 (V_4) recorded higher CGR at all growth stages and superior to CO 6 (V_1) and CO 7 (V_2). The results revealed that minimum tillage *fb* imazethapyr + imazamox (M_3) and conventional tillage (M_4) recorded higher leaf area index at flowering (2.90, 2.87) and at harvest (1.92, 1.75), respectively. The cultivar CO 8 (V_3) recorded higher LAD which was at par with VBN (Gg)2 (V_4) at all growth stages.

The results revealed that yield parameters as well as yield were influenced by tillage methods and cultivars. Minimum tillage followed by application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_3) resulted in higher number of pods and number of seeds per pod and was at par with conventional tillage method. Among the cultivars, higher values of yield components were observed in CO 8 followed by VBN (Gg)2. The 100 seed weight was not influenced by the methods of tillage but cultivars differed significantly. The protein content was not influenced by tillage methods and cultivars.

The cultivar Co 8 recorded the highest seed yield (736 kg ha^{-1}) and was differed significantly from other three cultivars. All cultivars performed better under minimum tillage followed by application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and conventional tillage followed by two hand weedings at 15 and 30 DAS. Among the interactions, the cultivar CO 8 in minimum tillage followed by imazethapyr + imazamox @ 80 g ha^{-1} recorded higher seed yield (942 kg ha^{-1}) and it was at par with conventional tillage.

The biological yield was higher (3127.41 kg ha^{-1}) in minimum tillage *fb* imazethapyr + imazamox (M_3) and was at par with conventional tillage (M_4) and were

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significantly differed from minimum tillage (M_1) and minimum tillage *fb* pendimethalin (M_2). The harvest index was not influenced by tillage methods and cultivars.

The results revealed that weed density and dry weight varied with tillage methods but not with cultivars. The weed density was lower in conventional tillage method which was at par with minimum tillage followed by herbicide sprays 30 DAS. Nineteen weed species were observed in experimental field. The predominant weed species were broad leaved weeds.

The soil nutrient status was not influenced by the cultivars. Among the tillage methods, minimum tillage method recorded higher values of organic carbon, available nitrogen, phosphorus and potassium after the experiment. The nutrient uptake was higher in minimum tillage followed by post emergence application of imazethapyr + Imazamox @ 80 g ha^{-1} at 20 DAS.

Economic analysis revealed that cultivar CO 8 grown under minimum tillage followed by imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_3V_3) recorded the highest gross returns and benefit - cost ratio. The highest income was obtained from minimum tillage *fb* imazethapyr + imazamox (M_3) (Rs.63608) followed by conventional tillage (M_4) (Rs. 59925). The highest BCR was realized from minimum tillage *fb* imazethapyr + imazamox (M_3) (1.53) followed by minimum tillage *fb* pendimethalin (M_2) (1.17) and conventional tillage (M_4) (1.14).

It is summarized from the present study that greengram cultivar CO 8 (V_3) grown under minimum tillage method followed by post emergence herbicide spray of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_3) can be recommended for summer rice fallows considering the yield and profitability.

Future Line of Work

- The nutrient dynamics under minimum tillage system
- Evaluation of new cultivars for different locations

REFERENCES

REFERENCES

Ahmad, A., Chowdhury, T., Taunk, S. K., Dewangan, D., and Singh, A. P. 2017. Pre and post emergence application of imazthapyr on N uptake, nodulation and microbial population of chickpea sown after rice in *Vertisols* of C. G. *Int. J. Curr. Microbiol. App. Sci.* **6**(6): 2844-2857.

Ahmad, R., Mahmood, I., Kamal, I., and Bukhari, S.A.H. 2004. Growth and yield response of three mungbean (*Vigna radiata* L.) cultivars to varying seeding rates. *Int. J. Agri. Biol.,* 6(3): 538-540

Alam, M. K., Islam, M. M., Salahin, N., and Hasanuzzaman, M. 2014. Effect of tillage practices on soil properties and crop productivity in wheat-mungbean-rice cropping system under subtropical climatic conditions. *Sci. World J.* 15p.

Ali, S., Patel, J. C., and Singh, J. 2013. Weed control in *kharif* greengram [*Vigna radiata* L. Wilczek]. *Bioinfolet* 10: 458-461.

Amarasingha, R., Suriyagoda, L., Marambe, B., Rathnayake, W., Gaydon, D., Galagedara, L., Punyawardena, R., Silva, G., Nidumolu, U., and Howden, M. 2017. Improving water productivity in moisture-limited rice-based cropping systems through incorporation of maize and mungbean: A modelling approach. *Agric. Water Manag.* 189: 111 - 122.

Andrade, D. S., Colozzi-Filho, A., and Giller, K. E. 2003. The soil microbial community and soil tillage. *Soil tillage agroecosystems.* 51-81.

Anikwe, M. A. N., Mbah, C. N., Ezeaku, P. I., and Onyia, V. N. 2007. Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (*Colocasia esculenta*) on an *Ultisol* in southeastern Nigeria. *Soil Tillage Res.* 93(2): 264-272.

Ansari, A. H., Kakar, A. A., Tareen, A. B., Barecht, A. R., and Kakar, G. M. 2000. Planting pattern and irrigation level effects on growth, yield components and seed yield of soybean (*Glycine max* L.). *Pakistan J. Agric. Sci.* **37**: 61–64.

Arif, M., Marwat, K. B., and Khan, M. A. 2007. Effect of tillage and zinc application methods on weeds and yield of maize. *Pak. J. Bot.* 39(5): 1583-1591. Available:http://www.fao.org/ag/ca/ index.html [08 July 2008].

Awada, L., Lindwall, C. W., and Sonntag, B. 2014. The development and adoption of conservation tillage systems on the Canadian Prairies. *Int. Soil Water Conserv. Res*. 2(1): 47 - 65.

Bahera, U. K. and Sharma, A. R. 2011. Effect of conservation tillage and performance of green gram-mustard-cowpea cropping system. *Soil Water Conserv.* 10(3): 233- 236.

Banjara, T. R., Pali, G. P., Tigga, B. K., Kumar, S., and Shori, A. 2017. Effect of different tillage practices on growth, yield and economics of chickpea (*Cicer arietinum L.*) under rainfed condition of Chhattisgarh. *Int. J. Curr. Microbiol. App. Sci.* 6(2): 1464 – 1470.

Behera, U. K., Mishra, A. K., Bishoyi, B. S., Behera, S. K., and Nayak, R. N., Ronanki, S., and Singh, S. 2014. Introduction of pulse crop in rice-fallow system through use of conservation agriculture practices in western Odisha. *J. Soil Water Conserv.* 13(4): 318 - 323.

Bhowaland, S. K. and Bhowmik, S. K. 2014. Performance of summer mungbean as affected by variety and date of harvest. *Trends Biosci*. 7(13): 1534-2014.

Bilalis, D. J., Karkanis, A., Papastylianou, P., Patsiali, S., Athanasopoulou, M., Barla, G., and Kakabouki, I. 2010. Response of organic linseed (*'Linum* *usitatissimum*' L.) to the combination of tillage systems, (Minimum, Conventional and No-Tillage) and fertilization practices: seed and oil yield production. *Aust. J. Crop Sci. 4*(9): 700.

Bindhu, J. S., Raj, S. K. and Girijadevi, L. 2014. Sustainable system intensification of sesamum (*Sesamum indicum*) through legume intercropping in sandy loam tract of Kerala. *J. Crop and Weed*, **10:**38-42.

Black, C. A. 1965. *Methods of Soil Analysis.* American Society of Agronomy, Winconsin, USA, 128p.

Borah, P., Devi, J., Sarma, D., and Chaurasia, N. K. 2017. Evaluation of performance of blends of green gram *Vigna radiata* (L.) Wilczek relative to their component cultivars in pure stands. *J. Pharmacog. Phytochem.* **1**:1061- 1064.

Buhler, D. D. 1992. Population dynamics and control of annual weeds in corn (*Zea mays*) as influenced by tillage systems. *Weed Sci.* 40(2): 241-248.

Buhler, D. D. 1995. Influence of tillage systems on weed population dynamics and management in corn and soybean in the central USA. *Crop Sci*. 35(5): 1247-1258.

Busari, M. A., Kukal, S. S., Kaur, A., Bhatt, R., and Dulazi, A. A. 2015. Conservation tillage impacts on soil, crop and the environment. *Int. Soil Water Conserv. Res*. 3(2): 119-129.

Chadha, M. L. 2010. Short Duration Mungbean: A new success in south Asia. Asia-Pacific Association of Agricultural Research Institutions c/o FAO Regional Office for Asia and the Pacific Bangkok, Thailand. pp. 3.

Chandra, A., Guru, S. K., and Thakur, T. C. 2017. Impact of different tillage practices on soil biochemical parameters, root and shoot growth and yield attributes of winter wheat. *J. Pharmacogn. Phytochem.* 6(5): 1915-1922

Chauhan, Y. S. and Williams, R. 2018. Physiological and agronomic strategies to increase mungbean yield in climatically variable environments of northern Australia. *Agron.* 8(6): 83.

Choudhary, A. K., Thakur, S. K., and Suri, V. K. 2013. Technology transfer model on integrated nutrient management technology for sustainable crop production in high value cash crops and vegetables in NW Himalayas. *Commun. Soil Sci. Plant Anal.* **44** (11): 1684-1699.

Das, A., Suri, V. K., Choudhary, A. K. 2014. Site-specific nutrient management approaches for enhanced nutrient-use efficiency in agricultural crops. Res. Rev. *J. Crop Sci. Technol*. 3(3): 1 - 6.

Dash, S. R. and Rautaray, B. K. 2017. Growth parameters and yield of green gram varieties (*Vigna radiata* L.) in east and south east coastal plain of Odisha, India. *Int. J. Curr. Microbiol. App. Sci.* **6**(10): 1517-1523.

Dastane, N. G. 1967. *A Practical Manual for Water Use Research*. Navbharath Prakashan, Poona, 105p.

Davis, A. S., Dixon, P. M., and Liebman, M. 2003. Using matrix models to determine cropping system effects on annual weed demography. *Ecol. Appl.* **14**:655-668.

De Vita, P., Di Paolo, Fecondo, G., Di Fonzo, N., and Pisanthae, M. 2007. No-tillage and conventional tillage effects on durum wheat yield, grain quality and soil moisture content in southern Italy. *Soil and Tillage Res*. **92**: 69-78.

Dhiman, S.D., Nandal, D.P. and Om, H. 2000. Productivity of rice (*Oryza sativa*)-wheat (*Triticurn aestivum*) cropping system as affected by its residue management and fertility levels. *Indian J. Agron*. 45: 1-5

Diaz-Zorita, Grove, M., Murdock, J. H., and Herbeck, L. 2004. Soil structural disturbance effects on crop yields and soil properties in a no-till production system. *Agron. J.* **96** (6), 1651-1659.

Directorate of Pulses Development. 2017. *Annual Report* 2017. GOI [Government of India] Vindhyachal Bhavan, Kanpur, 112 p.

FAO [Food and Agriculture Organization of the United Nations]. 2013. *Conservation Agriculture*. Agriculture and Consumer Protection Department, Rome.

FAO. 2016. Pulses are praised for their health, environmental and economic benefits. How can their full potential be tapped. Proc No. 128 dt b30.05.2016 – 19.06.2016of Global Forum on Food Security and Nutrition. p.73.

FAO [Food and Agricultural Organization]. 2008. Conservation Agriculture.

Gan, Y., Hamel, C., O'Donovan, J. T., Cutforth, H., Zentner, R. P., Campbell, C, A., Niu, Y., and Poppy, L. 2015. Diversifying crop rotations with pulses enhances system productivity. *Sci. Rep*. 5: 14625. doi: 10.1038/srep14625

Ghosh,T. K., Singh,R. P., Duhan,J. S., and Yadav, J. S. 2006. Response of moong cultivars to Rhizobial inoculation. *Legume Res*. 29(3): 233-234.

Gohil, K. O., Kumar, S. and Jat, A. L. 2017. Protein yield and nutrient uptake of summer green gram [*Vigna radiata* l. wilczek] as influenced by seed priming with plant geometry and nutrient management. *Int. J. Agric. Sci.* 9: 4832-4834.

Gomez, K. A. and Gomez, Z. A. 1984. Statistical procedures for research, A Wiley-Interscience publication, New York 657p.

Gorade, V. N., Chavan, L. S., Jagtap, D. N., and Kolekar, A. B. 2015. Response of green gram (*Vigna radiata* L.) varieties to integrated nutrient management in summer season. *Agric. Sci. Digest* .34 (1): 36-40.

Gosami, R. K., Hiramath, S. M., Chetti, M. B., Koti, R.V., and Saimath, P. M. 2009. Genotypic variation for physiological traits in relation to seed yield in greengram. *Ann. Plant Physiol.* 23(1):12-16.

Goswami, K. R., Choudhary, H., Sharma, M. K., Sharma, D., and Bhuyan, J. 2010. Evaluation of greengram genotypes for morphological, physiological traits and seed yield. *Ann. Plant Physiol.* 24(2): 115-120.

Gupta, R. P. and Dakshinamoorthi, C. 1980. *Procedures of Physical Analysis of Soil and Collection of Agro Meteorological Data.* Indian Agricultural Research Institute, New Delhi, 280p.

Guzha, A. C. 2004. Effect of tillage on soil micro relief, surface depression storage and soil water storage. *Soil Tillage Res.* 76: 105- 114.

Halvorson, A. D., Wienhold, B. J., and Black, A. L. 2001. Tillage and nitrogen fertilization influence grain and soil nitrogen in an annual cropping system. *Agron. J.* **93**: 836-841.

Huang, M., Chen, J., Cao, F., Jiang, L., and Zou, Y. 2016. Rhizosphere processes associated with the poor nutrient uptake in no-tillage rice (*Oryza sativa* L.) at tillering stage. *Soil and Tillage Res.* 163: 10-13.

Huggi, L. N. and Kalaghatagi, S. B. 2016. Production potentiality of crops after pigeonpea under different tillage systems during summer in upper Krishna command area. *J. Farm Sci.* 29(3): 340 - 343.

Imran, Khan, A. A., Inam, I., and Ahmad, F. 2016. Yield and yield attributes of mungbean (*Vigna radiata* L.) cultivars as affected by phosphorous levels under different tillage systems. *Cogent Food Agric.*[e-journal] 2. Available:http://dx.doi.org/10.1080/23311932.2016.1151982 [21 Dec. 2016].

Jackson, M. L. 1973. *Soil Chemical Analysis* (2nd Ed.). Prentice Hall of India, New Delhi, 498p.

Jan, A., Amanullah, H. A. and Blaser, B. C. 2012. Chickpea response to tillage systems and phosphorus management under dryland condition. *J. Plant Nutr.* 35(1): 64-70.

Jat, M. L., Gathala, M. K., Ladha, J. K., Saharawat, Y. S., Jat, A. S., Kumar, V. S., and Gupta, R. 2009. Evaluation of precision land leveling and double zero-till systems in the rice-wheat rotation: Water use, productivity, profitability and soil physical properties. *Soil and Tillage Res*. **105**: 112-121.

Kahlon, M. S., Lal, R., and Varughese, M. A. 2013. Twenty two years of tillage and mulching impacts on soil physical characteristics and carbon sequestration in Central Ohio. *Soil Tillage Res.* **126**: 151–158

Kar, G. and Kumar, A. 2009. Evaluation of post-rainy season crops with residual soil moisture and different tillage methods in rice fallow of eastern India. *Agric. Water Manag*. **96**: 931–938.

Kataria, K., Singh,S. P. and Yadav,R. S. 2018. Evaluation of post-emergence herbicides in greengram. *Ann. Agric. Res*. 39(1): 63 - 66.

KAU [Kerala Agricultural University]. 2016. *Package of Practices Recommendations: Crops* (15th Ed.). Kerala Agricultural University, Thrissur, 392p.

Kessel, V. C., and Hartley, C. 2000. Agricultural management of grain legumes: has it led to an increase in nitrogen fixation. *Field Crops Res.* 65: 165 – 181.

Khan, A. M., Jan,T., M., Marwat, K. B., and Arif, M. 2009. Organic and inorganic nitrogen treatments effects on plant and yield attributes of maize in a different tillage systems. *Pak. J. Bot. 41*(1): 99-108.

Khurshid, K., Iqbal, M., Arif, M. S., and Nawaz, A. 2006. Effect of tillage and mulch on soil physical properties and growth of maize. *Int. J. Agric. Biol*. 8(5): 593-596.

Korres, N. E. and Froud-Williams, R. J. 2002. Effects of winter wheat cultivars and seed rate on the biological characteristics of naturally occurring weed flora. *Weed Res*. 42(6): 417-428.

Kumar, J. 2000. Pulses: Towards a quantitative leap. In: Hindu Survey of Indian Agriculture. *The Hindu*, 2 Nov 2000, pp. 49 - 52.

Kumar, K., Prasad, Y., Mishra, S. B., Pandey, S. S., and Kumar, R. 2013. Study on genetic variability, correlation and path analysis with grain yield and yield attributing traits in green gram [*Vigna radiata* (l.) Wilczek]. *The Bioscan* **8**(4): 1551-1555.

Kumar, N., Hazra, K. K. and Nadarajan, N. 2014. Efficacy of post-emergence application of imazethapyr in summer mungbean (*Vigna radiata* L.) Legume Res.36 (2): 127-129.

Kumar, N., Hazra, K. K., and Nadarajan, N. 2016. Efficacy of post - emergence application of imazethapyr in summer mungbean (*Vigna radiata* L.). *Legum. Res*. **39**(1): 96-100.

Kumar, N., Singh, M.K., Ghosh, P.K., Venkatesh, M.S., Hazra, K.K. and Nadarajan, N. 2012. *Resource Conservation Technology in Pulse Based Cropping Systems.* Indian institute of Pulses Research, Kanpur, 32p.

Kumar, R., and Yadav, D. S. 2005. Effect of zero and minimum tillage in conjunction with nitrogen management in wheat (*Triticum aestivum*) after rice (*Oryza sativa*). *Indian J. Agron.* 50(1): 54-57.

Kumar, R., Paslawar, A. N., Singh, U., and Nagar, R. K. 2015. Effect of conservation tillage on growth, production and energetics of pigeonpea based intercropping system under rainfed area. *Ecoscan*. 9 (1-2): 153 - 157.

Lal, B., Gautam, P., Panda, B. B., Raja, R., Singh, T., and Tripathi, R. 2017. Crop and varietal diversification of rainfed rice based cropping systems for higher productivity and profitability in eastern India. PLoS ONE. e0175709. https:// doi. org/ 10.1371/ journal. pone. 0175709.

Lawn, R. J. 2004. Contributions to crop improvement and sustainable agriculture in tropical and subtropical Australia. Ph. D thesis, The University of Queensland, Brisbane, Australia. 81p.

Lee, Y.S., Lee, J. Y., Kim, D. K., Yoon, C. Y., Bak, G. C., Park, I. J., Bang, G. P., Moon, J. K., Oh, Y. J., and Min, K. S. 2014. A new high-yielding mungbean cultivar,"Samgang" with lobed leaflet. *Korean Breed. J.*, 36: 183 - 184.

Madhu, G. 2013. Response of mungbean (*Vigna radiata* L. Wilczek) genotypes to dates of sowing and foliar nutrition in *kharif* season. M. Sc. (Ag.) thesis, University of Agric. Sci., Dharwad, 106p.

Mahalakshmi, B. K., Reddy, P. J., Rao, K. L. N., and Rao, C. L. N. 2002. Performance of blackgram genotypes under rainfed situation. *Ann. Plant Physiol.* 16 (1): 48-51.

Mahata, K. R., Sen, H. S., and Pradhan, S. K. 1992.Tillage effects on growth and yield of blackgram (*Phaseolus mungo*) and cowpea (*Vigna unguiculata*) after wet-season rice on an alluvial sandy clay-loam in eastern India. *Field crop Res.* **29**:55-65.

Malik, A. Hassan, F. Waheed, A. Qadir, G., and Asghar, R . 2006. Interactive effects of irrigation and phosphorus on green gram *(Vigna radiata* L.*). Pak. J. Bot.* **38**(4): 1119-1126.

Malik, V. S., Swanton, C. J., and Michaels, T. E. 1993. Interaction of white bean (*Phaseolus vulgaris* L.) cultivars, row spacing, and seeding density with annual weeds. *Weed Sci.* 41(1): 62-68.

Marshall, E. J. P., Brown, V. K., Boatman, N. D., Lutman, P. J. W., Squire, G. R., and Ward, L. K. 2003. The role of weeds in supporting biological diversity within crop field. *Weed Res*. 43:77 - 89.

Meena, J. R., Umakant, K., Bahera, U. K., Chakrabarty, D., and Sharma, A. R. 2015. Tillage and residue management effect of soil properties, crop performance and energy rotation in green gram (*Vigna radiata*) under maize based cropping system. *Int. Soil Water Conser. Res*. **3**: 261-272.

Mitchell, S. B. and Carter, P. R. 2006. Influence of tillage on corn and soybean yield in the United States and Canada. *Crop Manag.* 5(1).

Muchow, R. 1985. Canopy development in grain legumes grown under different soil water regimes in a semi-arid tropical environment. *Field Crops Res*. 11: 99 - 109.

Murphy, S. D., Clements, D. R., Belaoussoff, S., Kevan, P. G., and Swanton, C. J. 2006. Promotion of weed species diversity and reduction of weed seedbanks with conservation tillage and crop rotation. *Weed Sci.* 54(1): 69-77.

Nanjappa, H. V. 2013. Effect of tillage and nutrient management practices on weed dynamics and yield of fingermillet (*Eleusine coracana* L.) under rainfed pigeonpea (*Cajanus cajan* L.) fingermillet system in *Alfisols* of Southern India. *Afr. J. Agric. Res.* 8(21): 2470-2475.

Nazeer, S., Malik, A. U., Nazir, G., and Ahmad, J. 2012. Effectiveness of tillage systems and farm manure levels on rice productivity. *J. Animal Plant Sci.* 22(2): 334 - 338.

NCAER [National Council of Applied Economic Research] 2014. India's Pulse Scenario. NCEAR, New Delhi 8p.

Omondi, J. O., Mungai, N. W., Ouma, J. P. and Baijukya, F. P. 2014. Effect of tillage on biological nitrogen fixation and yield of soybean (*Glycine max* L. Merril) varieties. *Australian J. Crop Sci*. 8(8):1140-1146.

Onyari C. A. N., Ouma, J. P., and Kibe, A. M. 2010. Effect of tillage method and sowing time on phenology, yield and yield components of chickpea (*Cicer* *arietinum* L.) under semi-arid conditions in Kenya. *J. Appl. Biosci.* 34: 2156 - 2165.

Pandey, R. K., Saxena, M. C., and Singh, V. B. 1978. Growth analysis of blackgram genotypes. *Indian J. Agric. Sci.* **45**: 466-473.

Parwada, C., Kamota, A., Karavina, C., and Chivende, T. 2014. Effect of tillage method on weed control and Zea mays (maize) yield under Zimbabwean dry conditions. *Academia J. Agric. Res. 2*(2): 49-53.

Pasricha, N. S., Bansal, S. K., Singh, K., and Deen, M. 2006. Reduced tillage for efficient management of crop residue, irrigation water and fertilizer nitrogen in wheat grown in rotation with rice [abstracts]. In: *Abstracts, 18th World Congress of Soil Science on Frontiers of Soil Science: Technology and Information Age*. 9-15, July, 2006, Philadelphia, USA.

Patel S. A., Chaudhari P. P., and Desai N. H. 2016. Yield and economics of greengram (*Vigna radiata* (L.) Wilczek) cultivars as influenced by integrated nutrient management. *Crop Res.,* **51**(1): 1-3.

Pathak, H., Tewari, A. N., Sankhyan, S., Dubey, D. S. Mina, U., Singh, V. K., Jain, N., and Bhatia, A. 2011. Direct seeded rice: Potentials, performance and problems- A review. *Curr. Adv. Agric. Sci.* 3(2):77-88.

Peter. O. A. O. 2008. The impact of tillage systems on soil microclimate, growth and yield of cassava (*Manihot utilisima*) in Midwestern Nigeria. *Afr. J. Agric. Res. 3*(3): 225-233.

Piper, C. S. 1967. *Soil and Plant Analysis.* Hans Publication, Bombay, 368p.

Pooniya, V., Choudhary, A. K., Dass, A., Bana, R. S., Rana, K. S., Rana, D. S., Tyagi, V. K. and Puniya, M. M. 2015. Improved crop management practices for sustainable pulse production: An Indian perspective. *Indian J. Agric. Sci.* 85 (6): 747 - 758.

Pooniya, V., Choudhary, A. K., Dass, A., Bana, R. S., Rana, K. S., Rana, D. S., Tyagi, V. K. and Puniya, M. M. 2015. Improved crop management practices for sustainable pulse production: An Indian perspective. *Indian J. Agric. Sci.* 85: 747 - 758.

Porpavai, S., Devasenapathy, P., Siddeswaran, K., and Jayaraj, T. 2011. Impact of various rice based cropping systems on soil fertility. *J. Cereals Oilseeds* **2**: 43-46.

Power, J. F., Willis, W. O., Gunes, D. L. and Peichman, G. A. 1967. Effect of soil temperature, phosphorus and plant age on growth analysis of barley. *Agron. J.* 59: 231-234.

Priya, T. B., Subramanyam, D., and Sumathi, V. 2015. Weed dynamics and yield of groundnut as influenced by varieties and plant population. *Indian J. Weed Sci.* 47(1): 75-77.

Rachaputi, R. C., Chauhan, Y., Douglas, C., Martin, W., Krosch, S., Agius, P., and King, K. 2015. Physiological basis of yield variation in response to row spacing and plant density of mungbean grown in subtropical environments. *Field Crops Res*. 183: 14 - 22.

Rasul, F., Cheema, M.A., Sattar, A., Saleem, M. F., and Wahid, M. A. 2012. Evaluating the performance of three mungbean cultivars grown under varying inter row spacing. *J. Anim. Plant Sci.* **22**(4): 1030-1035.

Reddy, P. J., Rao, C. L. N., Rao, K. L. N., and Mahalakshjmi, B. K. 2003. Evaluation of urdbean genotypes for growth, yield and yield attributes under rainfed upland vertisols in Krishna – Godavari Zone of Andhra Pradesh. *Ann. Plant Physiol*. 16(2): 103-105.

Roldan, A., Caravaca, F., Hernández, M. T., Garcıa, C., Sánchez-Brito, C., Velasquez, M., and Tiscareno, M. 2003. No-tillage, crop residue additions, and legume cover cropping effects on soil quality characteristics under maize in Patzcuaro watershed (Mexico). *Soil Tillage Res.* 72(1): 65-73.

Rusu, T. 2014. Energy efficiency and soil conservation in conventional, minimum tillage and no-tillage. *Int. Soil and Water Conserv. Res.*, 2(4): 42-49.

Samant, T. K. 2014. Evaluation of growth and yield parameters of greengram (*Vigna radiata* L.). *Agric. Update* **9**(3): 427-430.

Samant, T. K. and Patra, A. K. 2016. Effect of tillage and nutrient-management practices on yield, economics and soil health in rice (*Oryza sativa*) – green gram (*Vigna radiata*) cropping system under rainfed condition of Odisha. *Indian J. Agron.* **61**(2): 148-153.

Sangakkara, U. K. 2007. Effect of tillage and moisture levels on growth, yield and nodulation of common bean (*Phaseolus vulgaris*) and mungbean (*Phaseolus radiatus*) in the dry season *Indian J. Agron.* 49(1): 60 - 63.

Sarkar, S. and Singh, S. R. 2007. Interactive effect of tillage depth and mulch on soil temperature, productivity and water use pattern of rainfed barley (*Hordium vulgare L.*). *Soil Tillage Res*. **92**: 79–86.

Shafaqat, A., Ibin-i-Zamir, M. S., Mujahid, F., Farooq, M. A., Muhammad, R., Rehan, A., and Fakhir, H. 2016. Growth and yield response of wheat (*Triticum aestivum* L.) to tillage and row spacing in maize-wheat cropping system in semi-arid region. *Eurasian J. Soil Sci.* 5(1): 53 - 61.

Shakya, J. 2016. Performance of Green gram (Vigna radiata L. Wilczek) varieties under rainfed farming situation of Kymore Plateau subzone of M.P. M.Sc. (Ag) thesis, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, 108p.

Sharma, S. N., Prasad, R., and Singh, R. K. 2000. Influence of summer legumes in rice (*Oryza sativa*) - Wheat (*Triticum aestivum*) cropping system on soil fertility. *Indian J. Agric. Sci.* 70(6): 357-359.

Sharpe, R. R., Boswell, F. C., and Hargrove, W. L. 1986. Phosphorus fertilization and tillage effect on dinitrogen fixation in soybeans. *Plant and soil*. 96(1): 31-44.

Shersingh, P., Puniya, R., Sharma, A., Bazaya, B. R., and Kachroo, D. 2016. Effect of sowing dates and cultivars on growth, yield and nutrient uptake of summer mungbean (*Vigna radiata*). *Ind. J. Agron.* **61**(2): 256-258.

Sidar, S. 2017. Effect of different methods of tillage and conservation farming on finger millet (*Eleusine coracana* L.). M.Sc. (Ag) thesis, Indira Gandhi krishi vishwavidyalaya, Raipur, Chhattisgarh, 118p.

Siddique, K. H. M., Johansen,C., Turner, N.C., Jeuffroy, M., Hashem,A., Sakar, D., Gan, Y. and Alghamdi,S. 2012. Innovations in agronomy for food legumes. A review. *Agron. Sustain. Dev.* **32**: 45–64.

Siddique, M., Malik, M. F. A., and Awan, S. I. 2006. Genetic divergence, association and performance evaluation of different genotypes of mungbean (*Vigna radiata*). *Int. J. Agric. Biol*. 8: 793 - 795.

Simpson, J. E.., Adair, C. R., Kohler, G. O., Dawson, E. H., Dabald, H. A., Kester, E.B. and Hlick, J. T. 1965. Quality evaluation studies of foreign and domestic rices. *Tech. Bull. No. 1331 service*, U. S. D. A., 1-186.

Singh, A.K., Manibhushan, B. P., Singh, K. M., and Upadhaya, A. 2013. An analysis of oilseeds and pulses scenario in Eastern India during 2050-51. *J. Agric. Sci.* **5**(1): 241-249.

Singh, B. G., Rao, V. J. M., Suguna, C. A., and Rao, L. M. 1985. Varietal differences in growth and yield of mungbean (Vigna radiata (L.) Wilczek) during summer and kharif seasons. *Indian J. Plant Physiol.* 28: 2017-214.

Singh, D. and Singh, B. 2011. Breeding for tolerance to abiotic stresses in mungbean. *J. Food Legume*. 24: 83 - 90.

Singh, G., Kumar, R., and Kumar, S. 2006. Effect of tillage and nitrogen levels on growth and yield of maize (Zea mays L.). *Ann. Agric. Res.* 27(2): 198-199.

Singh, I. D. and Stoskopf, Y. C. 1971. Harvest index in cereals. *Agron J.* 63: 224-226.

Singh, P. K., Singh, S. K., Shukla, M. K., Singh, C., Kumari, M., Singh, R., and Prasad, P. 2016. Effect of different tillage practice, herbicide and *Rhizobium* on weed, yield and economics of Mung bean (*Vigna radiata* L.). *Int. J. Multidisciplinary Res. Dev.* 3(7): 257 - 259.

Singh, P. K., Singh, S. K.,Shukla, M. K., Singh, C., Singh, R., Singh, S. S. and Prasad, P. 2016. Growth and yield of greengram (*Vigna radiata* L.) as influenced by bio fertilizer, tillage practices and weed control methods. *Int. J. Multidisciplinary Res. Dev.* **3**(7): 254-256.

Singh, U. 2015. Effect of conservation tillage on growth, production and energetics of pigeonpea based intercropping system under rainfed area. *Ecoscan*. 9:153 - 157.

Tamang, D., Nath, R. and Sengupta, K. 2015. Effect of herbicide application on weed management in greengram [*Vigna radiata* (L.) Wilczek]. *Adv. Crop Sci.*

*Tech.*3:[e-journal] 163.Available: http://163.doi:10.4172/2329-8863.1000163 [21 Dec. 2016].

Thomas, A. G., Derksen, D. A., Blackshaw, R. E., Van Acker, R. C., Légère, A., Watson, P. R., and Turnbull, G. C. 2004. A multistudy approach to understanding weed population shifts in medium-to long-term tillage systems. *Weed Sci.* 52(5): 874-880.

Thomas, G. A., Dalal, R. C., and Standley, J. 2007. No-till effects on organic matter, pH, cation exchange capacity and nutrient distribution in a Luvisol in the semi-arid subtropics. *Soil Tillage Res.* 94(2): 295-304.

Varsa, E. C., Chong, S. K., Abolaji, J. O., Farquhar, D. A., and Olsen, F. J. 1997. Effect of deep tillage on soil physical characteristics and corn (Zea mays L.) root growth and production. *Soil Tillage Res. 43*(3-4): 219-228.

Verma, T.S. and Bhagat, R.M. 1992. Impact of rice straw management practices on yield, nitrogen uptake and soil properties in a wheat-rice rotation in northern India. Fert. Res., 33: 97-106

Vural, H. and Efecan, I. 2012. An analysis of energy use and input costs for maize production in Turkey. *J. Food Agric. Environ.* 10(2): 613 - 616.

Wallace, D. M. and Munger, H. M. (1965). Studies of the physiological basis for yield differences. 1. Growth analysis of six dry bean varieties. *Crop Sci.,* 5: 343·348.

Watson, D. J., 1947. Comparative physiological studies on the growth of field crops: I. Variation in net assimilation rate and leaf area between species and varieties and within and between years. *Ann. Bot.* 11: 41-76.

Weinberger, K. 2003. Impact analysis of mung bean research in south and southeast Asia. *Final report of GTZ Project. The World vegetable Center (AVRDC), Shanhua, Taiwan.*

Yadav, A., Suri, V. K., Kumar, A., Choudhary, A. K. and Meena, A. L. 2015. Enhancing plant water relations, quality and productivity of pea (*Pisum sativum* L.) through AM fungi, inorganic phosphorus and irrigation regimes in an Himalayan acid Alfisol. *Commun. in Soil Sci. and Plant Anal.* 46 (1): 80–93.

APPENDIX

APPENDIX

Weather parameters during the cropping period (December 2017 to March 2018)

Month	Temperature (^{0}C)		RH (%)	Rainfall (mm)	Wind velocity (km/h)	Sunshine hours
	Max.	Min.				
December, 2017	32.4	22.3	63	11.5	5.1	7.3
January, 2018	33.5	20.9	53	00.	5.4	8.2
February, 2018	35.7	22.5	47	5.2	5.7	9.5
March, 2018	36.7	24	59	33.2	3.3	8.0

PERFORMANCE OF GREENGRAM (*Vigna radiata* (L.) WILCZEK) CULTIVARS UNDER DIFFERENT TILLAGE METHODS

By
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ABSTRACT OF THE THESIS

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Abstract

Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods

An experiment entitled "Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods" was undertaken to study the response of selected greengram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage. The experiment was conducted during the period from December 2017 to March 2018 at Agronomy Farm, College of Horticulture, Vellanikkara.

Split plot design was adopted with three replications. The main plot treatments were four tillage methods *viz*., M_1 - minimum tillage (primary tillage only), M_2 - minimum tillage followed by pre-emergence application of pendimethalin @ 1 kg ha^{-1}, M_3 - minimum tillage followed by post-emergence application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and M_4 - conventional tillage (Primary and secondary tillage) followed by two hand weedings at 15 and 30 DAS. Sub plot treatments were four cultivars; V_1 –CO 6, V_2–CO 7, V_3–CO 8 and V_4 -VBN (Gg)2.

The growth attributes of greengram (plant height, number of branches and leaf area) at flowering and at harvest stages were influenced by tillage methods. Higher values were observed in minimum tillage followed by application of herbicide imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and the lowest in minimum tillage. Among the cultivars, CO 8 and VBN (Gg)2 had recorded higher growth parameters. The physiological parameters, CGR, LAI, LAD and number of nodules per plant also varied with tillage methods and cultivars.

The results revealed that yield parameters as well as yield were influenced by tillage methods and cultivars. Minimum tillage followed by application of

imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS resulted in higher number of pods and number of seeds per pod and was at par with conventional tillage method. Among the cultivars, higher values of yield components were recorded in CO 8 followed by VBN (Gg)2. Minimum tillage followed by application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS recorded higher seed yield (748 kg ha^{-1}) which was at par with conventional tillage. This was 102 per cent higher than yield from minimum tillage. The cultivar CO 8 recorded the highest seed yield (736 kg ha^{-1}) and differed significantly from other three cultivars. All cultivars performed better under minimum tillage followed by application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and conventional tillage followed by two hand weedings at 15 and 30 DAS. Among the interactions, the cultivar CO 8 in minimum tillage followed by imazethapyr + imazamox @ 80 g ha^{-1} recorded higher seed yield (942 kg ha^{-1}) and it was at par with conventional tillage.

The results revealed that weed density and dry weight varied with tillage methods but not with cultivars. The weed density was lower in conventional tillage method which was at par with minimum tillage followed by herbicide sprays.

The soil nutrient status was not influenced by the cultivars. Among the tillage methods, minimum tillage method recorded higher values of available nitrogen, phosphorus and potassium after the experiment. The nutrient uptake was higher in minimum tillage followed by post emergence application of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS. Economic analysis revealed that cultivar CO 8 grown under minimum tillage followed by imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_3V_3) recorded the highest gross returns and benefit - cost ratio.

Greengram cultivar CO 8 (V_3) grown under minimum tillage method followed by post emergence herbicide spray of imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_3) can be recommended for summer rice fallows considering the yield and profitability.