Original Research Article

Efficacy of early foliar spray intervention on alteration of physiological efficiencies and seed quality attributes of green gram (*Vignaradiata* L.)

ABSTRACT

The present study was focused on the evaluation of foliar spray treatment to arrest the flower drop in order to increase the seed set and seed yield in greengram.The crop of greengram*var.*CO 8 was raised by adopting the recommended package of practices during *rabi* season during 2019 and 2020 at Department of Seed Science and Technology, TNAU, Coimbatore. Foliar application of different nutrients *viz*., Nutrigold 0.50%, $ZnSO_4$ 0.10%, Mono ammonium phosphate 2%, as treatments were sprayed at bud initiation (30 days after sowing) and 7 days after flowering stages.Pulse wonder @ 5kg ha^{-1} was sprayed during peak flowering stage. Unsprayed plots served as control. During the investigations, data on flower production, arresting of flower drop, seed set, seed filling, seed yield and quality of greengram were recorded and studied.

In the study, significantvariations were observed due to the foliar applications. Days to 50 per cent flowering, number of flowers per plant, number of pods per plant, conversion efficiency percentage, pod yield $ha^{-1}$and seed yield ha^{-1}were significantly higher with foliar spray of Nutrigold 0.50% applied at bud initiation and 7 days later which was on par with Pulse wonder @ 5kg ha^{-1} appliedduring peak flowering stage. The percentage of flower drop was less inNutrigold0.50%(39.69%) which was on par with Pulse wonder @ 5kg ha^{-1} (41.04%)when

compared to control (52.02%). Seed quality parameters such as seed recovery, 100 seed weight, seed germination and vigour of seedlings were significantly higher in foliar spray of Nutrigold 0.50% when compared to other treatments.

From this study, it could be concluded that the foliar application of Nutrigold 0.50% during bud initiation and 7 days after flowering or Pulse Wonder @ 5kg/ ha during peak flowering could be effectively applied to maximize the flower production, arrest the flower drop and to improve the seed yield and quality in greengram.

Key words *:Greengram, Flower drop, Conversion efficiency, Foliar application, Nutrigold, Pulse wonder*

1. INTRODUCTION

Greengram is the third important pulse crop in the country after redgram and blackgramgrown in nearly 16 per cent of the total pulse area of the country. It is an excellent source of high quality protein (25%), Riboflavin, Thiamine and Vitamin C with high digestibility. It has been reported that greengram has been cultivated in India since ancient times. It is believed that greengramis a native of India and Central Asia and grown in these regions since prehistoric times. It is widely cultivated throughout the Asia, including India, Pakistan, Bangladesh, Srilanka, Thailand, Laos, Cambodia, Vietnam, Indonesia, Malaysia, south China, and Formosa. Greengramis a protein rich staple food. The biological value improves greatly when wheat or rice is combined with greengrambecause of the complementary relationship of the essential amino acids [1].

As per the World Health Organization, every man needs 50-60 g of pulses per day and Indian Council of Medical Research suggested, consuming 47 g of protein per day to meet out the daily requirement of body. But at present, the per capita availability of pulses is only less than 30 g

per day. It is particularly rich in Leucine, Phenylalanine, Lysine, Valine, Isoleucine, etc. In addition to being an important source of human food and animal feed, greengram also plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. It is a drought resistant crop and suitable for dryland farming and predominantly used as an intercrop with other crops.

India contributes more than 70% of world's greengram production. It is grown in about 4.5 million hectares with the total production of 2.5 million tonnes with a productivity of 548 kg/ha and contributing 10 % to the total pulse production. The states of Rajasthan (13.99 lakh ha), Karnataka (1.14 lakh ha), Madhya Pradesh (0.25 lakh ha), Haryana (0.16 lakh ha) and Gujarat (0.13 lakh ha) are the major producers of greengram in India. According to Government 3rd advance estimates, greengram production in 2022-23 is at 3.74 million tonnes. In Tamilnadu, Salem, Nammakkal ,Dharmapuri, Vellore, Thoothukudi, Virudhunagar, Tiruvannmalaiand Madurai are major districts contributes greengram production (Source: Directorate of Economics and Statistics, 2022-2023).

The yield potential of greengram is very low because of the fact that the crop is mainly grown in rainfed conditions with poor management practices and also due to various physiological, biochemical as well as inherent factors associated with the crop. Apart from the genetic makeup, the physiological factor *viz.,* insufficient portioning of assimilates, poor pod setting due to the flower abscission and lack of nutrients during critical stages of crop growth, coupled with a number of diseases and pests [2] were the reasons for the poor yield.

Greengram is basically indeterminate type of flowering and fruiting and there is a continuous competition for available assimilates between vegetative and reproductive sinks throughout the growth period [3]. Since, the source is highly limited in pulses with lowering translocation of assimilates to the growing reproductive sinks, leaf area is an important parameter to obtain higher source in terms of higher assimilate production. Major physiological constraints are flower drop and fruit drop.It has been reported that success of pod set in

greengram is only 11-32 per cent [4] due to immature pods are lost at later period because of a large proportion of available assimilates is sequestered in old pods. It might be due to that older pod produces hormones like ABA that promote the abortion of younger fruits.

Most legumes are unable to mobilize their assimilates stored prior to fruiting, so storage reserve formation in the seed depends heavily on assimilates formed during fruiting itself, and seed yield is likely to be extremely sensitive to adverse environmental influences during filling. As with the cereals, the increased protein content of the developing seed is largely at the expanse of nitrogen derived from the senescing mother plant (including the pod), although nitrogen fixation by root nodules during reserve deposition may argument this supply [5].

Nutrients play a pivotal role in increasing the seed yield in pulses [6].The soil nutrient content may not be always enough to fulfil crop requirement. Most of micronutrients like Fe and Mn are readily fixed in soil having alkaline $p^H$and plant roots are unable to absorb these nutrients adequately from dry top soil. Similarly, Ca and Mg are not easily translocated to leaves within the plant system [7]. Thus, the application of fertilizer containing macro and micronutrients in the soil may not be meeting the crop requirement for root growth and nutrient use. The alternative approach is to apply these micronutrients as foliar sprays.

Foliar application of micronutrients are 6-20 times more efficient than soil application irrespective of soil type [8]. In legumes, nitrogen is more useful because it is the main component of amino acid as well as protein [9]. Phosphorus is the second main critical plant nutrient but for pulses, it assumes primary importance, owing to its important role in root proliferation and thereby atmospheric nitrogen fixation. The role of phosphorus is to increase root development and pod formation. Potassium acts as a co-factor activating number of important enzymes vitally involved in energy transfer in the translocation of carbohydrates, N metabolism and also protein synthesis [10].Growth regulating substances /growth regulators are known to influence a wide array of

physiological parameters like alteration of plant architecture, assimilate partitioning, promotion of photosynthesis, uptake of nutrients (mineral ions), enhancing nitrogen metabolism, promotion of flowering, uniform pod formation, increased mobilization of assimilates to defined sinks, induction of synchrony in flowering, improved seed quality and delayed senescence of leaves in various crops [11].

Hormones play an important role on the vegetative and reproductive growth of any plant. At present, several synthetic hormones are employed by the farmers to boost the growth in the vegetative phase and subsequently to increase the yield. Several efforts have been made to increase the yield potential through breeding for high yielding varieties incorporating efficient irrigating methods and application of fertilizers, biocides and hormones. Nutrients such as DAP, Urea, $FeSO_4$, $ZnSO_4$ are known to significantly influence the yield of pulses [12].

Plant growth regulators (PGRs) which can improve the physiological efficiencies of plant could play a significant role in increasing crop yield and quality, when applied as foliar spray at proper crop growth stage in optimum concentration [13].Growth regulators, when applied as foliar spray at proper crop growth stage in optimum concentration could play a significant role in increasing crop yield and quality of produce in different field crops[14]. These plant growth regulators have been considered as software for plant development and improvement in crop productivity [15].Zn foliar spray at pre- flowering stage minimized the severity of Zn deficiency on the development of reproductive structure and enhanced the seed nutritional status like seed carbohydrate, storage proteins and also increase pod formation and seed yield [16].

Pulse wonder contains macro and micro nutrients that are water soluble and facilitates complete absorption of nutrients. Foliar application at peak flowering stage, reduces flower drops, tolerance drought and improves the yield by 10-20 per cent [17].Since, the greengram is predominately growing in marginal lands as rainfed crop in Tamil Nadu, the potential of the crop to express its vigour could not be explored. Besides, there is a continuous competition for availability of nutrients from vegetative to pod formation stage and hence there is an urgent need to supply

nutrients through foliar means during pod initiation to flowering stage to reduce the flower drop and also to increase the flower production thereby there will be a chance to get another 15-20 per cent increased yield.

2. MATERIALS AND METHODS

Field experiments were conducted at Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore with greengram*var*. CO8 during *rabi* season 2019 - 2020.The treatments consist of foliar spray of different chemicals and plant growth regulators Nutrigold 0.50%, ZnSO4 0.10%, Mono ammonium phosphate (MAP) 2%, as treatments weresprayed at bud initiation (30 days after sowing) and 7 days after flowering stages to study the flower production, flower drop arrest, seed set, seed filling, seed yield and quality of greengram. Pulse wonder @ 5kg ha-1 was sprayed during peak flowering stage. Unsprayed plots served as control.

2.1 Experimental Details

2.1.1. Design and experimental details

The field experiment was laid out with Randomized Block design (RBD). There were five treatments (T_1 to T_5) with five replications. The plot size adopted was 4 x 4 m^2. The total numbers of plots were 25. The crop of greengram*var.*CO 8 was raised in field number 37E at Department of Seed Science and Technology, TNAU, Coimbatore during *rabi* season during 2019 and 2020 by adopting the recommended package of practices. The details of the treatments are shown in chart 1.

Chart 1.Treatments details

Treatments		Details of foliar nutrient application
T_1	Nutrigold 0.50 %	Foliar spray at bud initiation (30 days after sowing) and 7 days after.
T_2	ZnSO4 0.1 %	Foliar spray at bud initiation (30 days after sowing) and 7 days after
T_3	MAP 2%	Foliar spray at bud initiation (30 days after sowing) and 7 days after

T_4	Pulse wonder 5 kg ha^{-1}	At peak flowering stage
T_5	Control	

The data obtained from experiment were analysed statistically adopting the procedure described by Panse and Sukhatme (1985) [18]. Wherever necessary, the per cent values were transformed to angular (arcsine) values before analysis. The critical differences (CD) were calculated at 5 per cent probability level. The data were tested for statistical significance. If the F test is non-significant, it was indicated by the letters NS.

2.1.2. Experimental materials

2.1.2.1Nutrigold : Is an organic plant growth promoter has 20% protein and is rich in nutrients and amino acids. Nutrigold improves growth rate and provides nutrients to the plant for quality production and increase the yield by 15 -20 per cent in field crops and vegetables.

2.1.2.2 Zinc is an essential element for plants that act as a metal component of various enzymes or as a functional structural or regulatory cofactor and for protein synthesis, photosynthesis, the synthesis of auxin, cell division, and fertilization. Also, zinc plays a special role in synthesizing proteins, RNA and DNA.

2.1.2.3 Pulse Wonder : Is a booster with nutrients and growth regulators for Pulses. Recommended to decreases flower shedding, Increase yield up to 20 per cent and Increase drought tolerance.

Yield attributes such as days to first flowering, days to 50 per cent flowering, number of flowers per plant number of pods per plant conversion efficiency percentage, flower drop percentage, pod yield per ha (kg), seed yield per ha(kg), seed recovery percentage and seed weight (g) were observed and data were recorded.

Then, the seeds were subjected to seed germination tests using paper media (Between Paper- BP) as per the guidelines prescribed by International Seed Testing Association - ISTA [19].

Four replicates of 100 seeds placed in between paper germination paper and kept in germination room maintained with 25±2^{0}C temperature and 95±2% relative humidity in the presence of continuous light. After 10 days, the normal seedlings have been counted and the germination has been recorded and it was expressed in percentage.All the data were subjected to statistical analysis and the results were discussed.

3. RESULTS

The investigations in greengram*var*. CO8 revealed that among different foliar applications, plants sprayed with Nutrigold 0.5% took less number of days for first flowering (32.5), it was on par with Pulse Wonder @5 kg /ha (33.6) and $ZnSO_4$0.1% (34.03). However, the unsprayed control took 35.1 days for first flowering [Table 1.]Nutrigold 0.5% registered the maximum number of flowers (72.35) followed by other foliar application (Pulse Wonder 67.35 and $ZnSO_4$0.1% 61.68 and unsprayed control-55.36). Application of Nutrigold 0.5% significantly improved the number of pods and registered 43.63 pods followed by Pulse Wonder @ 5 kg /ha (37.18) and $ZnSO_4$ 0.1% (31.1) which was 17.3 per cent more than the Pulse Wonder, while the control recorded minimum number of pods per plant (26.56) [Table 1.].

The Conversion efficiency of formation of pods from flowers showed significant variation among different foliar application**.** Among the nutrients, Nutrigold 0.5% registered the highest conversion efficiency of 60.30 per cent which was on par with Pulse wonder @5 kg (58.95%). The lowest conversion efficiency was recorded in control (48.29%) which was 24.8 per cent less than theNutrigold 0.5%. The percentage of flower drop was less in Nutrigold 0.5% (39.69) which was on par with Pulse wonder @5 kg (40.03).The percentage of flower dropwas more in unsprayed control (52.02) [Table 1.].

The results of the seed production and quality of seeds showed that among different foliar application, Nutrigold 0.5% recorded highest pod yield (1511.11 kg ha^{-1}) followed by Pulse wonder @

5 kg (1444.40 kg ha^{-1}) which was on par, while the lowest pod yield was recorded in control(1244.60 kg ha^{-1}). Similar to pod yield, seed yield also had greater significance due to the application of Nutrigold 0.5% and registered the maximum seed yield per hectare (713.3 kg ha^{-1}) which was on par with Pulse Wonder (705.6 kg ha^{-1}) while the lowest seed yield was recorded in control (583.0 kg ha^{-1}) [Table 2.].

Table 1. Influence of foliar spray of nutrients on physiological efficiencies and growth attributes in greengram*var*.CO8

Treatments	Number of days to first flowering	Number of days to 50 % flowering	Number of flowers $plant^{-1}$	Number of pods $plant^{-1}$	Conversion efficiency (%)	Flower drop (%)
T_1- Nutrigold 0.5%	32.5	38.5	72.35	43.63	60.30	39.69
T_2- $ZnSO_4$ 0.1%	34.2	39.2	61.68	33.05	54.56	41.04
T_3- MAP 2%	34.6	41.1	60.58	31.10	50.42	45.44
T_4- Pulse wonder @5 kg	33.6	38.9	67.35	37.18	58.95	40.03
T_5- Control	35.1	42.5	55.36	26.56	48.29	52.02
Mean	**34.0**	**40.04**	**63.46**	**34.30**	**54.50**	**43.64**
S.Ed	**0.872***	**0.635***	**1.558****	**0.600****	**1.417****	**1.066****
CD(*P* = 0.05)	**1.90**	**1.38**	**3.38**	**1.31**	**3.08**	**2.32**

Table 2. Influence of foliar spray of nutrients on seed quality parameters in greengram*var*.CO8

Treatments	Pod yield ha^{-1} (kg)	Seed yield ha^{-1} (kg)	Seed recovery (%)	100 seed weight (g)	Germination (%)	Vigour Index
T_1- Nutrigold0.5%	1511.11	713.3	79.26	5.13	82 (64.87)	2696

T_2- $ZnSO_4$0.1%	1388.90	681.1	74.89	5.03	78 (62.02)	2304
T_3- MAP 2%	1344.50	648.9	74.53	4.89	76 (60.66)	2284
T_4- Pulse wonder @5 kg	1444.40	705.6	78.24	5.14	80 (63.43)	2597
T_5- Control	1244.60	583.0	72.48	4.51	76 (60.66)	2067
Mean	**1386.70**	**666.38**	**75.88**	**4.94**	**78 (62.33)**	**2390**
S.Ed	**43.341***	**13.342***	**1.819***	**0.137***	**0.714***	**26.51***
CD(P = 0.05)	**94.43**	**29.07**	**3.96**	**0.28**	**1.56**	**57.77**

(*Figures in the parentheses indicates arc-sine values*)

Highest seed recovery of 79.26% was recorded in Nutrigold 0.5% which was on par with Pulse wonder @5 kg (78.24) while the lowest in control (72.48%). 100 seed weight differed significantly from each other. It was higher in Pulse wonder @5 kg (5.14 g) which was on par with Nutrigold 0.5% (5.13 g). The 100 seed weight was lower in control (4.51g) [Table 1.].

4. DISCUSSION

Among the various factors for low productivity in pulses, physiological problems like flower drop and premature shedding of reproductive structure diminished the number of potential sinks or accumulation of assimilates [20] which seems to be associated with nutrient deficiency and hormonal imbalance and ultimately with reduced translocation of drymatter to reproductive parts. The poor production potential of pulses is attributed to poor photosynthates of pods and seed setting, which may be improved through foliar application of macro and micro nutrients and growth regulators. Consequently, application of nutrient elements through foliar spray at appropriate stages of growth becomes important for their efficient utilization and better performance of the crop.

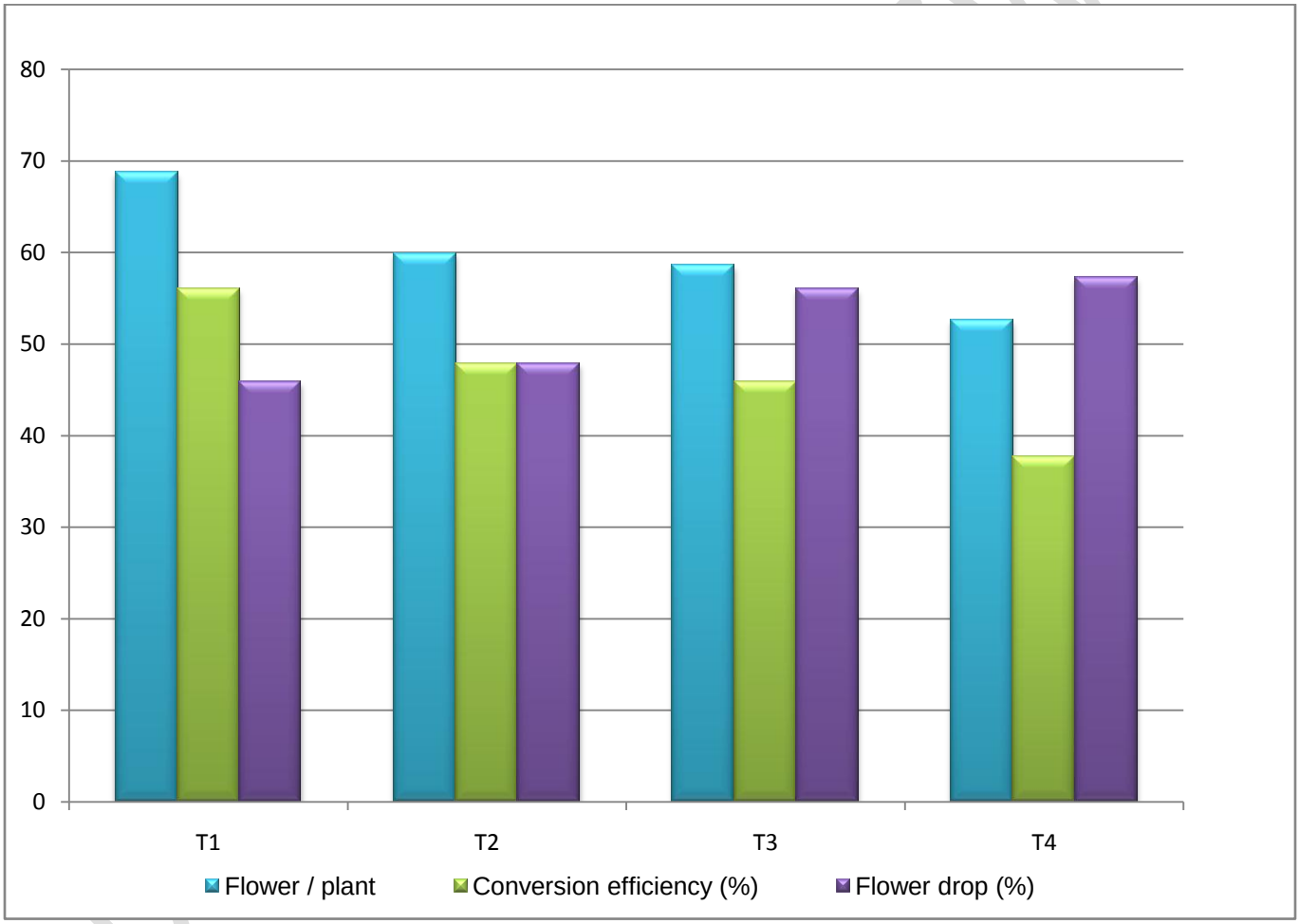
Foliar sprays are used for three main purposes. They are (i) to maintain optimum nutrition of a particular nutrient, (ii) to give a crop nutritional boost at a critical junctures of different phenophases and (iii) to correct deficiency disorders [21]. There are three ways of absorption of foliar nutrients; they

are (i) penetration through the epicuticular wax and the cuticularmembrane and (ii) penetration through the cell wall and plasma membrane.

It has been well established that the fertilizer elements which are absorbed through roots can also be absorbed with equal efficiency through foliage. Foliar application has been found to be favourable in short duration crops than medium and long duration ones where the fertilizer applied may not become fully available before maturity of crop.Keeping these points in view, the present study was taken up to develop crop management technique to increase seed set and filling in order to increase the seed yield and quality.

The investigations in greengram*var*. CO8 revealed that among different foliar applications, plants sprayed with Nutrigold 0.5% took less number of days for first flowering (32.5), it was on par with Pulse Wonder @5 kg /ha (33.6) and $ZnSO_4$ 0.1% (34.03). Nutrigold 0.5% registered the maximum number of flowers (72.35) followed by other foliar application (Pulse Wonder 67.35 and $ZnSO_4$ 0.1% 61.68 and unsprayed control - 55.36). The results of the present study are in agreement with the findings of Suganya (2014) in black gram [22]. The predominant effect of foliar application of nutrients during flower initiation and pod formation stage was seen as reduction in flower shedding percentage. This might have significantly increased the number of flowers per plant [19].Application of Nutrigold 0.5% significantly improved the number of pods and registered 43.63 pods followed by Pulse Wonder @ 5 kg /ha (37.18) and $ZnSO_4$ 0.1% (31.1) .This results are in agreement with the works of Valenciano*et al*. (2007) in common bean [23], Khurana and Chatterjee (2002) in pea[24], Seifinadergholi*et al*. (2011) in common bean [25] and Pandey *et al.* (2013) in black gram[16]. The higher number of pods per plants might be due to the application of balanced nutrition available in Nutrigold at critical phases from flower induction to pod development stages which may prevent the flower and pod drop. In general, foliar application of DAP 2 % twice at flower initiation and pod formation stages of crop growth significantly influenced the number of pods per plant.

The Conversion efficiency of formation of pods from flowers showed significant variation among different foliar application**.** Among the nutrients, Nutrigold 0.5% registered the highest conversion efficiency of 60.30 per cent which was on par with Pulse wonder @5 kg (58.95%) [Fig.1].These results are in conformity with the results of Kamaraj and Krishnaswamy (2003) inrice [26], Korzeniowska (2008) in wheat [27] and Liew*et al.* (2012) in rice [28]. This might be due to the absorption of abundant nutrients by the plants as suggested by Sarika*et al.* (2006) in linseed [29].



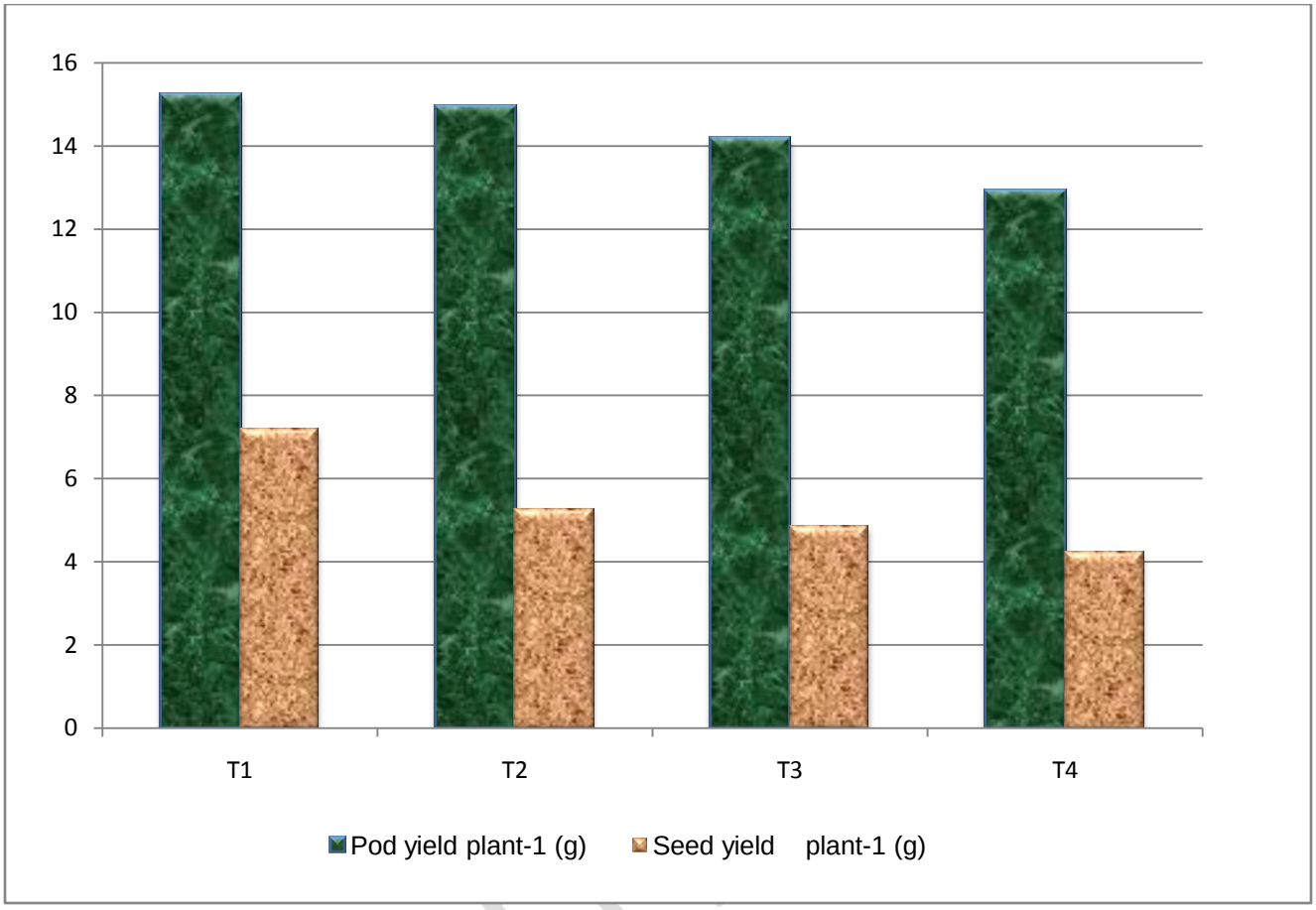
Treatments

T_1Nutrigold 0.50%T_2 Pulse wonder @ 5 kg $ha^{-1}$$T_3$ $ZnSO_4$ 0.1% T_4 Control

Fig 1.Influence of foliar spray of nutrients on number of flowers / plant, Conversion efficiency and flower drop (%) in greengram*var*.CO8

During the field investigation, the percentage of flower drop was less in the plots sprayed with Nutrigold 0.50 % which was on par with the plots sprayed with Pulse wonder @5 kg which showed a decrease of 23.70 per cent and 21.10 per cent respectively over unsprayed control.[Fig.1].The results are in conformity with the results of Shetty *et al*.(1992) in Bengalgram[30] and Parimala*et al.* (2013) in chickpea [31].This might be due to the prolonged assimilatory activity of leaves which would have decreased the flower drop and hence increased the number pods per plant. Supplementary foliar application during flowering was found to increase seed set and prevent premature abortion of embryos, enrich the source sink ratio thereby improves the seed quality.

The results of the seed production and quality of seeds showed that among different foliar application, Nutrigold 0.5% recorded highest pod yield (1511.11 kg ha^{-1}) followed by Pulse wonder @5 kg (1444.40 kg ha^{-1}) which was on par, while the lowest pod yield was recorded in control(1244.60 kg ha^{-1})[Fig.2].Similar to pod yield, seed yield also hadgreater significancedue to application of Nutrigold 0.5% and registered the maximum seed yield per hectare (713.3 kg ha^{-1}) which was on par with Pulse Wonder (705.6 kg ha^{-1})[Fig.2].The arrest of flower drops by 23.7 per cent due to the application of Nutrigold 0.5% and 21.1 per cent by Pulse Wonder over control might be the one of the reason for increased yield in pod as well as seeds.



Treatments

T_1Nutrigold 0.50% , T_2Pulse wonder @ 5 kg ha^{-1} T_3ZnSO_4 0.1% T_4 Control

Fig 2. Influence of foliar spray of nutrients on pod yield and seed yield plant^{-1} in greengram*var*.CO8

The reason for the increased yield might be due to the effective translocation of nutrients from source to sink of the crop[32]and also presence of bioactive substances in nutrigold*viz*., amino acid, vitamins and minerals could have resulted in increase of yield[33].Thus, it could have enhanced the yield attributes like number of pods per plant, number of seeds and 100 seed weight and also the higher dry matter production and nutrient uptake of green gram would be the possible reason for increased yield. This positive effect might be due to the better absorption of nutrients applied through foliage leading to better activity of functional root nodules resulting in more leaf area, dry matter production and uptake of nutrients. This could have led to more flower production and subsequently pod formation and other yield attributing characters. This is in conformity with the results of Abbas *et al*. (1994) in blackgram[34], Solaiappan andRamaiah (1990) in red gram [35]. It is also reported that

the absorption and transportation of micronutrients inside the plant system is much easier when foliar application of nutrients are combined with micronutrients [36].

On seed quality evaluation, seed recovery, 100 seed weight, germination and seedling vigour index were maximum in Nutrigold 0.5% which was on par with Pulse wonder @5 kg. This results are in support with the findings of Kathiresan and Duraisamy (2001) in *Sesbani aculeate*[37], Pradeep and Elamathi (2007) in green gram [38]and Vinothkumar*et al.* (2013) in soybean[39].The increased seed weight due to foliar application ofNutriglod might be due to the increased mobilization of metabolites of nutrients to the reproductive sinks resulting into a greater accumulation of food reserves into the seed resulting in enhanced carbohydrate metabolism and ultimately healthy seed.

5. CONCLUSION

From this study , it could be concluded that the foliar application of Nutrigold 0.50% during bud initiation and 7 days after flowering or Pulse Wonder @ 5kg/ ha during peak flowering could be effectively applied to maximize the flower production, arrest the flower drop by 23.0 per cent and to improve the seed yield and quality in greengram.

COMPETING INTERESTS :

Authors have declared that no competing interest exist.

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