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Influence of crop establishment practices and microbial inoculants on plant growth and nutrient uptake of summer green gram (*Vigna radiata)*

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ABSTRACT

A field experiment was carried out during summer season of 2018 at ICAR-Indian Agricultural Research Institute, New Delhi to study the effect of crop establishment practices and microbial inoculation on growth and nutrient uptake by summer green gram [Vigna radiata (L.) Wilczek]. The experiment was laid out in split plot design and treatments were replicated thrice. The experiment included nine treatment combinations including three crop establishment practices viz., conventional tillage, zero tillage and zero tillage with chick pea residue @ 2.5 t/ha in main plots and three microbial inoculation treatment viz. control (no inoculation), dual inoculation of Rhizobium + Phosphate Solubilizing Bacteria (PSB) and combined inoculation of Rhizobium+ PSB+ Arbuscular Mycorrhiza (AM) Fungi in sub-plots. Results showed that zero tillage with 2.5 t ha^{-1}residue produced significantly higher growth parameters like crop growth rate (CGR) and net assimilation rate (NAR) at 20, 35 and at 50 DAS, grain (968.6 kg ha^{-1}) and (2415.3 kg ha^{-1}) stover yield. The same treatment showed significantly higher uptake of N, P and K in grain and stover over other two treatments. Seed inoculation with Rhizobium+ PSB + AM Fungi was significantly superior to other two treatments with regard to growth parameters like CGR and NAR at 20, 35 and at 50 DAS, grain yield, stover yield and uptake of N, P and K in grain and stover of summer green gram. Highly positive correlations were recorded between grain yield and yield attributes like grain yield and pods/plant, grain yield and grains/ pod, grain yield and test weight of summer green gram.

Key words: Microbial inoculants, CGR, NAR, nutrient uptake, residue and zero tillage, summer green gram, yield, zero tillage

INTRODUCTION

India is the world's largest producer of pulses where pulses are the second main source of protein after cereals in Indian diet (Narayan and Kumar, 2015). Pulses play a significant role in providing nutritionally balanced diet. Pulses are the major source of dietary protein for vegetarian population. Total pulse area in India is 304.0 lakh hectares (ha) and the production is 223.30 lakh tonnes. Green gram stands third after chickpea and pigeon pea among the pulses. It has occupied 34.00 lakh ha area and contributes 23.70 lakh tonnes in pulse production in the country (DAC, 2018-19). Green gram being a legume crop, has the inherent ability to get much of its nitrogen requirement from the atmosphere by forming a symbiotic relationship with *Rhizobium* bacteria in the soil. Besides, green gram, a short duration pulse crop can be grown as catch crop during *kharif* and summer seasons. Intensive tillage-based agriculture practices without recycling of organic resources resulting in loss of soil fertility which then reduce the overall productivity of green gram and add to production cost also. In intensive cropping system conventional tillage results in soil erosion problems leading to reducing the productivity of the soil thus causing the nutrient imbalance in the crop (Tilakaratne and Tilakaratne, 2003). So, there is need for alternative method of crop establishment for the purpose of protecting soil degradation, increasing water use efficiency, reducing the cost of production of summer crops and improving crop productivity which have positive effects on the bio-physico-chemical properties of a soil. Zero-tillage has the potential to save time, energy, water and labour during crop establishment. Crop residues are important natural resource which recycle the nutrients and have other benefits in improving soil bio-physico-chemical properties. Microbial inoculants (biofertilizers) are organic products containing a specific micro-organism which are derived from the nodules of plant or from soil of root zone (rhizosphere). They offer important technology to Indian agriculture holding a promise to balance

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many of the shortcomings of conventional chemical based technologies. Some microbial inoculants like *Rhizobium* will fix atmospheric nitrogen by living symbiotically, phosphate solubilising bacteria (PSB) helps solubilisation of various inorganic and organic phosphates added to the soil (Bhavya *et al.*, 2018). Arbuscular mycorrhiza (AM) Fungi plays a vital role in supplementing major plant nutrients (like N and P) and micro nutrients like Fe, Zn requirement of crops. Microbial inoculants offer a cheaper, low capital intensive, non-bulky and renewable source, low price plant nutrient improving fertilizers and ecofriendly route to boost farm productivity depending upon their activity of mobilizing nutrients (Jaga and Sharma, 2015). The risk in intensive and chemical based agriculture has amplified more and more complications; hence it is very challenging to sustain farm returns. Furthermore, resource deprivation due to overexploitation is emerging as a key menace in enhancing productivity. With these facts, a field experiment was conducted to evaluate the effects of crop establishment practices and microbial inoculation on profitability and quality of summer green gram**.**

MATERIALS AND METHODS

The field experiment was conducted at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi during summer the season of 2018. The soil of the experimental field was sandy loam in texture with 61.2% sand, 15.6% silt and 23.2% clay. The soil was low in organic C (4..4 g kg^{-1}), low in available N (195.8 kg ha^{-1}) and available P (10.5 kg ha^{-1}) and medium in available K (230.0 kg ha^{-1}) with pH of 7.6. The experiment was conducted in a split-plot design with nine treatment combinations, keeping three methods of crop establishment viz. conventional tillage (CT), zero tillage (ZT) and zero tillage with residue (ZT+R) in main plots and three microbial inoculants treatments *viz*. dual inoculation of *Rhizobium*+ Phosphate Solubilizing Bacteria (PSB), the combined inoculation of *Rhizobium*+ PSB + Arbuscular Mycorrhiza (AM) Fungi and control (no seed inoculation). In sub-plots seeds were treated with *Rhizobium* (500 g ha^{-1}) and PSB (500 g ha^{-1}) and soil application (10 kg ha^{-1}) of AM Fungi done before sowing. Nitrogen, phosphorus and potassium were uniformly applied as basal at the rate of 20, 40 and 20 kg ha^{-1}, respectively to all plots. Other agronomic practices were followed as per the standard packages of practices to raise the green gram crop. The growth and physiological attributes were recorded as per the standard procedure *i.e.* five plants in each plot were selected at random and tagged. These plants were used to record biometric observations at different stages of crop growth. CGR and NAR 20, 35 and at 50 DAS were calculated by using the data on dry weight and leaf area index (LAI). The processed plant and grain samples were assessed using standard procedures for N, P, Kcontent and their uptake by grain and stover at harvest was calculated. At harvest, grain and stover yields were recorded separately for each plot and reported at 12% moisture. The data obtained from the experiment were statistically analyzed using the F-test as per standard procedure to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Crop growth rate and net assimilation rate

The growth indices like crop growth rate (CGR) and net assimilation rate (NAR) of summer green gram were significantly influenced due to the methods of crop establishment and microbial inoculations at 20 DAS and 35 DAS. CGR and NAR at 20 DAS and 35 DAS were significantly higher in zero tillage with residue treatment followed by conventional tillage and lowest in zero tillage treatment (Table 1). Similar results were reported by Meena *et al.* (2015). Amongst microbial inoculation treatments, combined inoculation of *Rhizobium* + PSB +AM Fungi recorded highest CGR and NAR at 20 DAS and 35 DAS followed by dual inoculation of *Rhizobium* + PSB and lowest was in control(Table 1). This may be due to inoculation of *Rhizobium* and PSB which produced appreciable higher leaf area index and dry matter accumulation per plant at 20 DAS and 35 DAS. Similar results were reported by Gajera *et al.* (2014).

Grain and stover yield

Among the methods of crop establishment, grainyield (968.6 kg ha^{-1}) and

Table 1: Influence of crop establishment methods and microbial inoculation on grow parameters and yield of summer green gram

Treatment		Nitrogen		Phosphorus		Potassium	
		Grain	Stover	Grain	Stover	Grain	Stover
Method of crop establishment (ME)							
Conventional tillage		31.8	42.6	4.87	7.92	13.2	39.9
Zero tillage		22.2	35.9	2.97	6.39	9.49	35.8
Zero tillage with residue		35.6	50.2	5.42	8.78	15.0	44.7
SEm±		0.50	1.61	0.10	0.15	0.45	0.56
LSD (P=0.05)		1.97	6.3	0.48	0.60	1.75	2.23
Microbial inoculation (MI)							
Control (no inoculation)		25.3	38.1	3.66	10.6	10.1	36.4
Rhizobium+ PSB		29.8	43.8	4.42	11.9	12.8	41.5
Rhizobium+ PSB + AM Fungi		34.1	48.4	5.07	12.9	14.6	44.1
SEm±		0.39	1.32	0.10	0.15	0.31	0.51
LSD(P=0.5)		1.21	4.08	0.32	0.46	0.96	1.59
Interaction (ME x MI)							
Factor (B) at same level of A	S Em ±	0.87	1.94	0.13	0.16	0.34	0.53
	LSD(P=0.05)	NS	NS	NS	NS	NS	NS
Factor (A) at same level of B	S Em ±	0.75	1.76	0.02	0.17	0.42	0.54
	LSD(P=0.05)	NS	NS	NS	NS	NS	NS

stover yield (2415.3 kg ha^{-1}) were the highest in zero tillage with residue and lowest in zero tillage (Table 2).Similar results were recorded by Khan *et al.* (2016) in green gram sown under zero tillage and adequate vegetative mulch on the soil surface which gave higher yield comparable with or even higher than those obtained under conventional tillage. Highest yield under zero tillage with residue was reported in maize and wheat crops by Raghavendra *et al.* (2017). This might be due to the fact that well-managed soil under zero till condition with crop residue application could support sustainable crop production through improved soil quality with higher soil organic carbon and available nutrients. Regular and appropriate addition of crop residue played role in improving the enzymatic activity of soil along with other benefits that are important for nutrient cycling, as well as for increasing crop productivity (Rajkumara *et al.*, 2014). Among the microbial inoculant treatments, combined inoculation of *Rhizobium* + PSB+ AM recorded significantly higher grain yield (940.7 kg ha^{-1}), stover yield (2387.2 kg ha^{-1}) as compared to other two seed inoculation treatments. This could be ascribed to the larger availability and uptake of nitrogen and phosphorus due to additive effect of biofertilizers in improving nutritional environment which enhanced the growth through higher branches and dry matter, photosynthetic area, production of assimilates and their translocation to reproductive parts, thereby amplified the yield attributes and ultimately the crop yield. The significantly higher straw yield due to biofertilizer application could be attributed to higher vegetative growth as a result of effective nutrients utilization which were absorbed by extensive root system and prolific shoot development on account of improved nourishment (Yadav *et al.*, 2017). Similar results were reported by Dongare *et al.* (2016) in green gram and Shekhawat *et al.* (2018) in black gram.

Nutrient uptake

Uptake of N, P and K by grain and stover varied significantly due to methods of crop establishment and microbial inoculant treatments in summer green gram (Table 2). Among the method of crop establishment, N, P and K uptake in grain and stover was significantly higher in zero tillage with residue as compared to other two treatments and lowest in zero tillage. Similar results were reported by Meena *et al.* (2015). This might be due to increased uptake of nutrients, suppressed the growth of weeds, increased the moisture availability and moderated the soil temperature. Thus, reduced crop weed competition for nutrients increased the biomass accumulation which ultimately increased the grain yield of crops and nutrientuptake in grain and biomass (Behera *et al.,* 2007).Residue retention improved the total N, Cand other soil nutrients, which resulted in greaterN uptake by grain and stover.

Amongst microbial inoculation treatments combined inoculation of *Rhizobium* + PSB + AM Fungi contributed significantly highestN, P and Kuptake by grain and stover as compared to other two treatments and lowest uptake in control. The increased availability of these nutrients in the root zone coupled with increased metabolic activity at cellular levels might have increased nutrient uptake and their accumulation in the vegetative plants. An improved metabolism to greater translocation of these nutrient to reproductive organs of the crop and ultimately increased the content in grain and straw (Mohammad *et al.*, 2017). The combined inoculation of seeds with PSB + VAM was more beneficial in enhancing all the above parameters due to increased solubilization and mineralization of organic phosphorus and availability of nitrogen and phosphorus.

Table 2: Influence of crop establishment methods and microbial inoculation on uptake of nutrients (kg ha^{-1}) in grain and stover of green gram

Treatment	CGR (g m^{-2} day^{-1})			NAR (g m^{-2} day^{-1})			Grain yield (kg ha^{-1})	Stover yield (kgha^{-1})
	0-20 DAS	20-35 DAS	35-50 DAS	0-20 DAS	20-35 DAS	35-50 DAS		
Method of crop establishment (ME)								
Conventional tillage	2.92	12.3	8.09	32.3	10.4	1.73	920.6	2305.5
Zero tillage	2.77	11.6	8.08	30.8	8.9	1.38	674.7	2098.5
ero tillage with residue	2.94	15.8	8.44	34.9	12.3	1.85	968.6	2415.3
SEm±	0.003	0.28	0.18	0.32	0.36	0.10	11.70	24.10
LSD (P=0.05)	0.01	1.10	NS	1.09	1.41	NS	40.20	94.02
Microbial inoculation (MI)								
Control (no inoculation)	2.75	11.9	7.94	32.9	9.2	1.52	762.9	2226.0
Rhizobium+ PSB	2.91	13.4	8.26	33.9	10.4	1.58	851.7	2306.2
Rhizobium+ PSB + AM Fungi	2.98	14.4	8.41	34.9	11.2	1.86	940.7	2387.2
SEm±	0.003	0.25	0.13	0.29	0.21	0.12	10.50	23.80
LSD (P=0.05)	0.01	0.77	NS	0.91	0.64	NS	33.70	73.30
Factor (B) at S Em ±	0.004	0.32	0.21	0.49	0.28	0.14	14.04	26.8
same level of A LSD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Factor (A) at S Em ±	0.004	0.36	0.23	0.41	0.21	0.14	16.7	27.30
same level of B LSD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

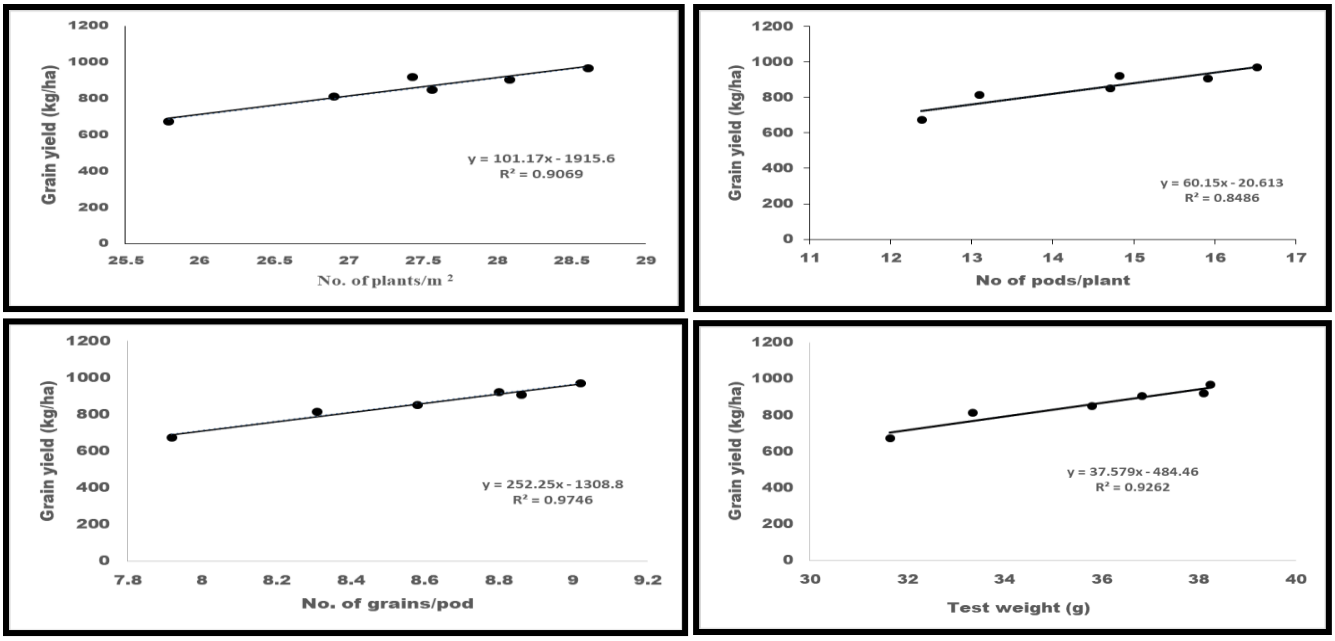

Fig 1: Relationship between grain yield and yield attributes of green gram under the influence of crop establishment methods and mic

There was a highly positive correlation between grain yield and yield attributes of green gram (Fig. 1). The correlation between grain yield and no. of plants/m^2, no. of pods/plant, no. of grains/pod and test weight were 90.6%, 84.9%, 97.5% and 92.6%, respectively. Crop establishment methods along with microbial inoculation led to better growth and yield attributes of summer green gram, which resulted in to higher yields.

It was concluded from the results that the combined inoculation of *Rhizobium* + PSB+ AM Fungi may be used in summer green gram crop established through zero tillage method of crop establishment with @ 2.5 t ha^{-1} crop residue for attaining better crop growth, productivity and nutrient uptake.

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