Response of Green Gram (*Vigna radiata (L.))Wilczek* to Inter Row Spacing and Phosphorus under Semi-arid Conditions of Eritrea

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ABSTRACT

Green gram *(Vigna radiata (L.) wilczek,*) commonly known as moong or mung bean or golden gram was introduced to Eritrea as a pulse crop by Ministry of Agriculture at its National Agricultural Research Institute (NARI) in collaboration with Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) in 2012. But its agronomic practices for semi-arid conditions of Eritrea are not yet standardised. Therefore , to find the optimum inter row spacing and phosphorus dose for its higher productivity ,a field experiment was conducted at the experimental farm of Hamelmalo Agricultural College, Keren, Eritrea during summer 2015 and 2016. The experiment was conducted in randomised complete block design (RCBD) with 12 treatment combinations of two factors consisting of four inter row spacing (Broadcast, 18cm, 30cm, and 45cm) and three phosphorus levels (0, 20 and 40 kg P_2O_5 ha^{-1}) each replicated thrice. The results of the study revealed that sowing of K-26 bold seeded variety either by broadcast method or at 18cm inter row spacing at10cm plant to plant spacing fertilized with 40kg P_2O_5 ha^{-1} through DAP fertilizer drilled at the time of sowing proved significantly superior to increase growth, yield attributes and seed yield of green gram.

Key words: Green gram, Phosphorus level, Row spacing, Nodulation, Weed count, Seed yield.

INTRODUCTION

Legumes are cultivated in the highlands and mid lands of Eritrea covering about 20,000 ha of land annually (Anonymous, 2007). Faba bean, chick pea, grass pea, lentil, cowpea and field pea are the common legumes that are widely grown in Eritrea and are the part of main diet of the Eritrean society. They are mostly used as main dish (*shiro*), snacks (*titko or migo*), fresh green (*shewit*), and roasted (*kolo*) and bread (*kicha*). The inexpensive, high-quality plant protein that legumes possess makes them important substitutes to the expensive animal product proteins.They exhibit good drought resistance and can be an option in marginal areas where other cereal crops cannot be planted. This makes them potentially very valuable for crop diversification in low rainfall conditions.

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Among the pulses, Green gram (*Vigna radiata (L.)Wilczek,*) also called as mung bean or golden gram is considered as a poor man's meat containing almost double amount of protein as compared to cereals. It has good digestibility and flavor. It contains 62.62% carbohydrate, 23.86% protein, 1.15% fat, 3.7 % ash,48 mg vitamin C, 132 mg calcium, 367mg phosphorus, 1246mg potassium, 15mg sodium,18.6mg magnesium and 1450 kJ Energy (USDA,2010),apart from thiamin, riboflavin, niacin vitamins and special amino acids like tryptophan, lysine, methionine, leucine, and isoleucine. Hence, from the nutritional point of view, mungbean is perhaps the best among all other pulses. In addition to this it also improves the soil fertility through biological nitrogen fixation to the tune of 30-40kg N ha^{-1}(IIPR, 2009) which plays a vital role in sustainable agriculture.

Green gram was introduced in Eritrea by the Ministry of Agriculture at National Agricultural Research Institute (NARI) in collaboration with Association for Strengthening Agriculture Research in Eastern and Central Africa (ASARECA) in 2012. It was given for cultivation to the farmers of Zoba Anseba and Gash Barka as inter crop with Sorghum and Pearl millet. The production of this crop was observed to be good and motivated farmers to grow this legume as intercrop because it is drought tolerant, early maturing and therefore it secures against total crop failure. But due to lack of package of agronomic practices for its cultivation under local agro-climatic conditions, its potential as a sole or intercrop has not yet been exploited in Eritrea.

Among the various agronomic practices, optimum nutrient management and plant population are important for increasing productivity of green gram. Out of the major nutrients, phosphorus is considered as the key element for obtaining the higher yield of legume crops, as it plays an important role in process of photosynthesis, root formation, growth, development, seed yield and enhancement of maturity of the crop. Phosphorus also reduces the harmful effects of excess nitrogen and imparts resistance to crop plants against diseases. Supply of phosphorus to legume increase the number and size of root nodules and nitrogen fixing potentiality of rhizobium. (Patil and Jadav, 1994 and Hossain and Hamid, 2007). Ahmed et al (1986) found that phosphorus application up to 60 kg $P_2O_5ha^{-1}$ increased both the dry matter accumulation and seed yield of mung bean. Similarly optimum plant populations which can be manipulated by inter or intra row spacing contributes to the high yield because thick plant population will not get proper light for photosynthesis and is easily attacked by diseases. On the other hand very thin population will not be able to fully utilize the resources and thus reduce the yield (Pookpakdi and Pataradilok, 1993). Singh *et al*. (1990) reported that row spacing of 20 and 30 cm and plant spacing of 5 and 10 cm resulted in significantly higher seed yield of green gram compared to 50 cm row spacing and 15 cm plant spacing during both summer and rainy seasons.

Green gram being a new crop to this country no systematic research has been done on its method of sowing and phosphorus requirement as a sole or intercrop. Therefore, keeping in view the above facts in mind, the present investigation was conducted to standardise the row spacing and phosphorus level for higher productivity of green gram under semi-arid conditions of Eritrea.

MATERIALS AND METHODS

The field experiment was carried out at the experimental farm of Hamelmalo Agricultural Collage, during summer 2015 and 2016. The site is located in Zoba Anseba of Eritrea at 15^0 52’ 18’’ N latitude, 38^0 27’ 55’’ E longitude and altitude of 1280 meter above mean sea level. The area experiences a mean annual rainfall of 513.5 mm, maximum temperature of 34.7^0C and minimum temperature of 11.1^0C. It falls under semi-arid mid-land region of Eritrea.

The soil of the experimental field was sandy loam in texture with moderately alkaline pH (8.07), low in total N (0.05 %), very low in Phosphorus (2.04ppm), low in Potassium (0.18cenmol/kg) and with electrical conductivity of 0.13dsmol/m.

The bold seeded variety K-26 of green gram, which was introduced to Eritrea in the year 2012, was used in the present experiment. The field experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications and 12 treatment combinations of two factors consisting of three phosphorus levels (0, 20 and 40 kg P_2O_5 ha^{-1}) and four inter-row spacing (broadcast (farmers method), 18cm, 30cm and 45cm). The treatments were allocated randomly to gross plots of size 4mx2.7m in each of the three replications after proper seedbed preparation and experiment layout manually. Crop was sown manually on July 9 and July2 during 2015 and 2016, respectively by keeping inter row spacing as per treatments and uniform plant to plant spacing of 10cm. In broad cast treatment, seed equal to the quantity used in 18cm row spacing was broadcasted and mixed in upper 7cm soil layer on the prepared seedbed. Phosphorus was applied as per the treatments by using di-ammonium phosphate (DAP) fertilizer. The16kg N ha^{-1} supplied by 40kg P_2O_5 ha^{-1} through DAP was equalized in all other treatments by applying required amount of urea. Thinning was done at 15 days after sowing (DAS) to maintain the recommended plant density per plot. First weeding was done at the time of thinning and second weeding was done at 35 DAS. Five plants in each plot were randomly selected to record the data on different growth, development, nodule count and yield attributes. The weed count data was recorded by placing 50cmx50cm quadrate at random in each plot at 15 days after second weeding. The samples taken for dry matter were oven dried at 70^0C until constant weight was achieved.

Crop was harvested when about 80% of the pods became black from 6.93 m^2, 6.93 m^2, and 7.35 m^2 and 6.3 m^2 net plot area in plots having broadcast, 18cm, 30cm, and 45cm treatment combinations, respectively by keeping one border row and 25cm from each side of the plot as non-experimental area. . Seed yield and biological yield were recorded from the net plot area and converted to per hectare. The harvest index was calculated by dividing the seed yield by biological yield per plot.

The data obtained were statistically analysed in RCBD design using Analysis of Variance (ANOVA) with the help of GENSTAT 14 statistical computer package software at 5% level of significance.

RESULTS AND DISCUSSION

The weather conditions during first year of the experimentation were comparatively more favorable than second year for the growth, development and yield of the crop because of receipt of higher and uniform distribution of rainfall (302.5mm) as compared to second year when only 235mm of rainfall was received. As a result comparatively higher seed yield of green gram was obtained during the year 2015 as compared to the year 2016.

The results emanated in two years study have been presented in Tables 1-5 and discussed with cause and effect relationships

Effect on growth

The data on effect of row spacing and phosphorus levels on plant height, dry matter, effective nodules and weed count have been presented in Table1.The data reveal that row spacing did not influence the plant height and dry matter per plant of green gram significantly during both the years of experimentation. Effective numbers of nodules per plant were not significantly affected by the row spacing during both the years.

Row spacing influenced the weed population significantly during the first year but the differences were not significant during the second year. During the first year broadcast and 18 cm row spacing being statistically at par reduced the weed population significantly over 30cm and 45cm row spacing due to the smothering effect of higher mung bean population and early canopy formation in narrow row spacing.

Phosphorus levels did not significantly influence plant height, dry matter and nodule count during both the years of study. However, addition of phosphorus numerically increased the plant height, dry matter and nodulation over no phosphorus application. Weed population was not affected significantly by phosphorus levels during both the years of experimentation.

The row spacing and Phosphorus levels did not interact significantly to influence the growth, nodulation and weed count during both the years of experimentation.

Effect on development

The data on effect of different treatments on days taken to flowering and maturity of green gram have been presented in Table 2. A perusal of the data indicate that row spacing did not influence the time taken for flowering and maturity of green gram during the second year but during first year row spacing caused significant influence on time taken to flowering and maturity. Sowing at 18cm row spacing resulted in significantly earliest flowering and maturity of the crop over other row spacings.

Phosphorus levels did not influence the time taken to flowering and maturity of the crop during both the years. However, numerically increasing phosphorus levels caused comparatively earliness in flowering and maturity of the crop during both the years.

On an average the crop took 42-45 days and 65-68 days for flowering and maturity, respectively which helped it to escape the moisture stress due to withdrawal of rains in later part of the crop development.

Row spacing and Phosphorus levels did not interact significantly to influence the days taken for flowering and maturity of the crop.

Effect on yield attributes

The data on effect of treatments on yield contributing characters have been presented in Table 3. A critical perusal of the data reveal that effective plant population, number of pods/plant, number of branches /plant were significantly affected by row spacing during both the years of experimentation. However, 1000 seed weight was not affected significantly during both the years. Although increase in row spacing increased the number of pods per plant and number of branches per plant significantly due to mutual competition free environment, but the effective plant population decreased significantly which ultimately reduced the seed yield of green gram with increased row spacing (Table 4.). These findings are in agreement with those of El-habbasha et al (1996) who also reported increase in number of pods per plant with lower plant population of mung bean.

Further perusal of the data in Table 3 reveal that phosphorus levels did not influence 1000seed weight and number of pods significantly during both the years, effective plant population during the first year and number of branches per plant during second year of experimentation. However, pods per plant increased numerically with the increase in phosphorus levels during both the years. Mitra et al (1999) also reported similar increase in number of pods /plant with increase in phosphorus levels .Significantly highest effective plant population was obtained with 40kg P_2O_5 ha^{-1} during the second year of experimentation**.** During first year of study 20kg P_2O_5 ha^{-1} being statistically at par with 40kg P_2O_5 ha^{-1} produced significantly higher number of branches per plant over no phosphorus application.

Row spacing and Phosphorus levels did not interact significantly to influence the yield attributes of the crop during both the years.

Effect on yields

The data regarding effect of treatments on biological yield, stover yield, seed yield and harvest index of green gram have been presented in Table 4. A cursory glance at the data reveal that while row spacing significantly influenced the biological yield and stover yield only during the second year of experimentation, the seed yield was influenced significantly during both the years of study. However, row spacing did not influence the harvest index significantly during both the years. During the first year of the study, biological and stover yields were not influenced significantly by row spacing. But during the second year , broadcast method of sowing resulted in significantly highest biological and stover yield which may be ascribed to the higher and non-uniform total plant population but lower effective plant population. Row spacing of 18cm was the next best because of higher effective plant population (Table 3) as well as total plant population of green gram and lower weed count (Table1) as compared to other row spacing. These results are in agreement with those of Ihsanullah et al (2002) who also obtained higher biological yield at narrow row spacing of 20cm as compared to 43 row spacing. Row spacing of 18cm being statistically at par with broadcast method of sowing resulted in significantly higher seed yield of green gram over other row spacings. It may be ascribed to the efficient utilization of light, moisture, nutrients and space by the plant population at 18cm inter row spacing resulting in comparatively higher effective plant population and 1000 seed weight (Table 3).The row spacings of 30cm and 45cm being statistically at par were next best in seed yield because of low effective plant population, but higher number of pods and branches per plant (Table 3) during both the years of experimentation. These results are in agreement with those of Singh et al (1990) who also reported higher seed yield of green gram at 20cm and 30 cm row spacings compared to 50cm row spacing. These findings are further in conformity with those of Sekhon et al (1994) who recorded 15% higher seed yield of green gram at 20cm row spacing over 30cm row spacing. Although the harvest index was not influenced significantly by the row spacings but numerically highest harvest index (37.3) was obtained with 18cm row spacing during both the years.

A perusal of data in Table 4 further revealed that phosphorus levels under study did not significantly influence the biological yield, stover yield and harvest index of green gram during both the years and the seed and stover yield during the first year of experimentation. However, during second year 40kg P_2O_5 ha^{-1} produced significantly highest seed yield over 0 and 20 kg P_2O_5 ha^{-1} which is attributed to higher effective plant population, 1000 seed weight, number of pods and branches per plant (Table 3) at higher level of phosphorus. This finding is in corroboration with those of Mohammed et al (2004) who obtained higher seed yield of green gram at 30 to 60 kg P_2O_5 ha^{-1} and of Patel and Patel (1994) who reported highest seed yield at 40kg P_2O_5 ha^{-1}.

Biological yield, stover yield and harvest index of green gram were not affected significantly by the interaction of row spacing and phosphorus levels during both the years. However, seed yield was influenced significantly by their interaction during the second year of experimentation.

A critical perusal of the row spacing and phosphorus interaction data in Table 5 reveal that although in each of the row spacing, increase in phosphorus levels increased the seed yield numerically, but significantly highest increase in seed yield (1754 kg ha^{-1}) was obtained with combination of 40kg P_2O_5 ha^{-1} and broadcast sowing. However, it was statistically at par with combination of 18cm row spacing and 40kg P_2O_5 ha^{-1}(1512 kg ha^{-1}) and broadcast sowing with 20kg P_2O_5 ha^{-1}(1528 kg ha^{-1}). These results are in agreement with those of Kumar and Singh (1993) and Shukla and Dixit (1996) who reported that 40kg P_2O_5 ha^{-1} and 30cm row spacing gave highest seed yield of 701.1 kg ha^{-1} and 860 kg ha^{-1}during first and second year of study, respectively in sandy loam soils of India.

CONCLUSION

It can be concluded from the study that growing of green gram by broadcast method or 18cm row spacing and drilling of 40kg P_2O_5 ha^{-1} through di-ammonium phosphate (DAP) at the time of sowing resulted significant increase in growth, yield attributes and seed yield of green gram under semi-arid conditions of Eritrea. However, for getting uniform distribution of plant population and ease of intercultural operations, sowing in rows at 18cm row spacing should be preferred over broadcast method of sowing.

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TABLE 1. Effect of treatments on growth parameters, effective nodules and weed count

Treatments	Plant height (cm)		Effective nodules (No. plant^{-1})		Dry matter (g plant^{-1})		Weed count (No. m^{-2})	
Row spacing(cm)	2015	2016	2015	2016	2015	2016	2015	2016
Broadcast	43.4	44.7	4.0	3.2	166.0	16.8	2.9	10.4
18	44.0	38.8	3.8	3.3	150.0	16.1	3.3	11
30	46.4	40.1	3.8	3.4	162.8	15.9	4.8	9.7
45	41.1	44.6	3.6	4.6	177.9	19.2	6.0	10.7
LSD (0.05)	NS	NS	NS	NS	NS	NS	0.88	NS
Phosphorus levels (kg ha^{-1})								
0	42.8	39.8	3.7	3	157.5	16.5	3.9	10.7
20	44.9	43.9	3.4	3.5	169.2	16.9	4.1	10
40	43.6	40.9	4.3	3.6	166.3	17.7	4.8	10
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV%	10.2	13.9	13.5	44.7	25	19.4	21.5	11.7
Row spacing x Phosphorus levels	NS	NS	NS	NS	NS	NS	NS	NS

NS=Non-significant

TABLE 2. Effect of treatments on development of green gram

Treatments	Days taken to flowering		Days taken to maturity	
	2015	2016	2015	2016
Row spacing(cm)				
Broadcast	47.4	42.1	69.7	66.2
18	42.3	42.1	64.3	66.4
30	46.2	42.6	68.8	67.2
45	46.6	42.1	67.9	68.7

LSD (0.05)	3.32	NS	3.66	NS
Phosphorus levels (kg ha^{-1})				
0	47.5	42.6	69.3	67.4
20	45.4	42.1	67.3	67.3
40	44.0	42	66.4	66.7
LSD (0.05)	NS	NS	NS	NS
CV%	5.5	2.3	7.5	3.5
Row spacing x Phosphorus levels	NS	NS	NS	NS

TABLE 3. Effect of treatments on yield contributing characters of green gram.

Treatments	**Effective plant population** (No.m^{-2})		**1000seed weight**(g)		**No. of pods** (No. plant^{-1})		**No. of branches** (No. plant^{-1})	
	2015	2016	2015	2016	2015	2016	2015	2016
Row spacing(cm)								
Broadcast	26.6	30.9	54.8	51.9	21.0	23	8.2	6.2
18	49.2	51.8	53.7	53.8	17.0	21.9	7.8	5.9
30	27.8	30.0	53.9	53.6	23.0	27.4	9.7	7
45	17.3	20.9	52.8	56.0	26.0	32.4	10.2	8
LSD (0.05)	2.94	1.68	NS	NS	3.35	0.60	0.97	0.30
Phosphorus levels (kg ha^{-1})								
0	30.6	32.6	54.4	53.7	19.9	25.9	8.4	6.5
20	30.9	33	52.9	53.8	22.3	25.8	9.6	6.5
40	29.6	34.5	54.0	53.9	23.3	26.9	8.9	7.3
LSD (0.05)	NS	1.45	NS	NS	NS	NS	0.84	NS
CV%	9.9	5.1	10.2	9.1	15.7	23.8	11.1	16.7
Row spacing x Phosphorus levels	NS	NS	NS	NS	NS	NS	NS	NS

NS= Non-significant S= Significant

TABLE 4. Effect of treatments on seed yield, Stover yield, biological yield and harvest index of green gram.

Treatments	Seed yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Harvest index (%)	
	2015	2016	2015	2016	2015	2016	2015	2016
Row spacing(cm)								
Broadcast	2016	1533	3564	2763	5750	4296	35.1	35.7
18	2281	1358	3669	2284	6116	3642	37.3	37.3
30	1918	1136	3467	2083	5541	3186	34.6	34.6
45	1747	1124	3446	2116	5141	3240	34.0	34.7
LSD (0.05)	317.2	205.1	NS	111.4	NS	327.5	NS	NS
Phosphorus levels (kg ha^{-1})								
0	1990	1177	3598	2066	5988	3382	33.2	34.8
20	1977	1241	3584	2138	5277	3666	37.5	33.9
40	2004	1447	3426	2048	5646	3802	35.5	38.1
LSD (0.05)	NS	117.6	NS	96.5	NS	NS	NS	NS
CV%	16.3	16.4	20.9	20.3	18.7	18.5	10.5	12.5
Row spacing x Phosphorus levels	NS	S	NS	NS	NS	NS	NS	NS

NS= Non-significant S= Significant

TABLE 5. Interaction effect row spacing and phosphorus levels on seed yield (kg ha^{-1}) of green gram during 2016.

	Phosphorus levels (kg ha^{-1})		
Row spacings (cm)	**0**	**20**	**40**
Broadcast	1316	1528	1754
18	1315	1249	1512
30	1002	1102	1305
45	1076	1083	1215
LSD (0.05)		355.2	