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EFFECT OF PLANT POPULATION ON CHARACTER EXPRESSION OF FIVE MUNGBEAN GENOTYPES UNDER DIFFERENT SOIL FERTILITY

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ABSTRACT

Plant density and soil fertility are two components of micro environment affecting genetic expression. The research was conducted at Muneng Experiment Farm in Probolinggo from March to May 2013. Two factors consisted of five mungbean genotypes (MMC679-2C-GT-2, MMC647d-GT-2, MMC554d-GT-2, MMC601f-GT-1 and Vima-1) and three levels of plant population (200,000, 333,333 and 500,000 plants ha^{-1}) were evaluated at two soil fertility managements (with and without fertilization). The treatments were arranged in split plot design and replicated three times. All growth parameters observed were higher in more fertile soil. The increasing plant population triggered plants to grow taller, but reduced chlorophyll content index (CCI), number of trifoliate leaf per plant (LN), leaf area per plant (LA), total dry matter per plant (TDM), number of pods and seed weight, and nutrient uptake of individual plant. Grain yield production per unit area was not significantly different because of plant population compensation. All genotypes tested were suitable to be planted on population of 200,000 and 333,333 plants ha^{-1}. With proper fertilization and population management, the genetic potential can be expressed by 3.5 t ha^{-1} for MMC554d-GT-2, 2.4 t ha^{-1} for MMC601f-GT-1 and Vima-1, 2.2 t ha^{-1} for MMC679-2C-GT-2, and 2.3 t ha^{-1} MMC647d-GT-2.

Keywords: mungbean; population; soil fertility

INTRODUCTION

Genetics and environmental interaction determine crop productivity. Sunlight, water availability, nutrients and temperature are environmental factors that influence the plant growth. Interaction between adjacent plant in utilizing environmental factors, especially sunlight, water and nutrients affect crop productivity. Adverse effect of interaction between individual plants can be minimized by proper crop and soil management.

Mungbean productivity in farmer level management during the last five years (2008-2012) was 1.1 to 1.2 t ha^{-1} (Ministry of Agriculture, 2012), even though potential yield of mungbean varieties released is 1.5-2.5 t ha^{-1} (ILETRI, 2012). Yield gap between potential and actual yield can be minimized through good management practices.

Grain yield production is determined by genetic potential, plant population (Mansoor, Khan, Ayaz, Zubair, & Nadim, 2010) and fertilizer management (Hussain, Baloch, Yang, Sanaullah, & Bashir, 2014). High potential yield of genotype is characterized by the large of leaf area and high biomass accumulation (Mondal, Hakim, Juraimi, Azad, & Karim, 2011). However, plants require adequate space to grow in a population. In accordance with plant population, proper plant spacing management has an important role in maximizing yield (Ahamed, Nahar, Rahmatullah, Faruq, & Alamgir, 2011; Kabir & Sarkar, 2008) because it affects the degree of competition between individual plant to acces potential capacity of land such as light, water and nutrient. High plant population increases competition between plant and reduce occupation of plant to get light, water and nutrient. Individual plant at low population produce more branch and pod, but number of pod per unit area become low so therefore reduce yield (G. Singh et al., 2003) as well as less efficient in land use (Sullivan, 2003).

Mungbean yield decreases as plant population density increases, while the number of pods per plant increases as population decreases. Yield per unit area generally increases as population density increase to certain level near upper limit. Optimum population of mungbean

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varies over location. The highest grain yield in Punjab, India attained at population of 40 plants per m^2 with a spacing of 25 × 10 cm (G. Singh et al., 2011), at AVRDC, Taiwan obtained in a population of 20 plants per m^2 at a spacing of 50 × 10 cm, and 30 plants per m^2 in Bangladesh (Hossain, Ali, & Uddin, 2011), 25 plants per m^2 in Iran (Rafiei, 2009). Mungbean in Pati, Central Java produces better growth parameters at spacing of 30 × 30 cm rather than 30 × 20 cm (Budiastuti, 2000).

The aim of this research was to study the response of five genotypes of mungbean with different agronomic characters to different plant population and land fertility.

MATERIALS AND METHODS

The research was conducted at Muneng Experiment Farm in Probolinggo ($7^0$48'06.4" S; $113^0$09'41.5" E; altitude 10 m asl). The seed sowed at March 15th and harvested at May 17th 2013. Materials used in the research were mungbean seed of MMC679-2C-GT-2, MMC647d-GT-2, MMC554d-GT-2, MMC601f-GT-1, Vima-1, inorganic fertilizer and organic fertilizer. Phonska (15-15-15) and SP36 (36% P_2O_5) use as source of inorganic fertilizer, while Petroganik use as source of organic fertilizer. Agronomic characteristic of mungbean genotypes presented in Table 1.

Two factors trial consisted of five mungbean genotypes (MMC679-2C-GT-2, MMC647d-GT-2, MMC554d-GT-2, MMC601f-GT-1 and Vima-1) and three levels of plant population (200,000, 333,333 and 500,000 plants ha^{-1}) were evaluated at two soil fertility managements (with and without fertilization). Population treatment of 200,000, 333,333 and 500,000 plants ha^{-1} obtained by dibling seed with 40 cm interrow and 25 cm, 15 cm and 10 cm between plant holes in the row, two seeds per hole. Fertilizer treatment use 37.5 kg N ha^{-1}, 73.5 kg P_2O_5 ha^{-1}, 37.5 kg K_2O ha^{-1} (equivalent to 250 kg Phonska ha^{-1} + 100 kg ha^{-1} SP36) and 5 t ha^{-1} Petroganik, and all applied before sowing. The combination of genotype and plant population treatments was laid out in split plot design and replicated three times. Plant population was set up as main plot and genotype as sub plot. Mungbean seeds were sowed in plots sizing of 3.6 m × 4.5 m with 50 cm space interplot. Weeding, pest and disease control conducted according to their conditions. The plant was harvested at physiological maturity.

Observation consisted of soil analysis (pH, C-organic, total N, available P and exchangeable K) at 25 days after planting (DAP) and plant tissue analysis (N, P, K) at 35 DAP. Growth parameter observed at 25, 35, 45 DAP consist of plant height, leaf chlorophyll index (Chlorophyl meter SPAD-502), leaf area (disk method), number of leaves and dry weight of leaves and stems. The growth analyses like relative growth rate (RGR) and nett assimilation rate (NAR) was carried out following the formulas of Fitter & Hay (1987):

$$\text{RGR} = \frac{lnW2 - lnW1}{t2 - t1};\ \text{NAR} = \frac{lnL2 - lnL1}{L2 - L1} \times \frac{W2 - W1}{t2 - t1},$$

Where :
W1 and W2 = sampling weight at times 1 and 2; L1 and L2 = leaf area at times 1 and 2, respectively. Observation at harvest consists of number and weight of matured pod, dry grain weight, and weight of 100 seeds. Grain weight at harvest measured from an area of 3.6 m × 2 m. Variance analysis used to detect effect of treatment, and mean comparation using Least Significant Different (LSD) at 5% level of significancy.

Table 1. Agronomic characteristics of five mungbean genotypes

No	Genotypes	Flowering (day)	Maturity (day)	Reproductive phase (day)	Plant height (cm)	Seed weight (g 100 seeds^{-1})
1	MMC679-2C-GT-2	32	50	19	46.4	5.59
2	MMC647d-GT-2	35	51	17	65.8	5.63
3	MMC554d-GT-2	36	54	18	75.6	5.97
4	MMC601f-GT-1	36	53	17	69.4	6.59
5	VIMA-1	34	51	17	47.1	6.40

Table 2. Soil chemical properties at different fertilization treatment

Variable	Method	0-20 cm		20-40 cm	
		L1[1)]	L2	L1	L2
pH-H_2O	1:5	6.6	6.7	7.4	7.4
N total (%)	Micro Kjeldahl	0.10	0.12	0.08	0.07
C-organic (%)	Kurmis	1.28	1.50	1.17	1.18
P (ppm P_2O_5)	Bray 1 extraction	30.84	51.82	23.85	21.81
K (me $100g^{-1}$)	1 N NH4-asetat pH 7 extraction	0.83	2.21	0.64	0.62

Remarks: 1) L1= check (no fertilization); L2= fertilization at rate of 37.5 kg N ha^{-1} + 73.5 kg $P_2O_5 ha^{-1}$ + 37.5 kg K_2O ha^{-1} + 5 t ha^{-1} Petroganik

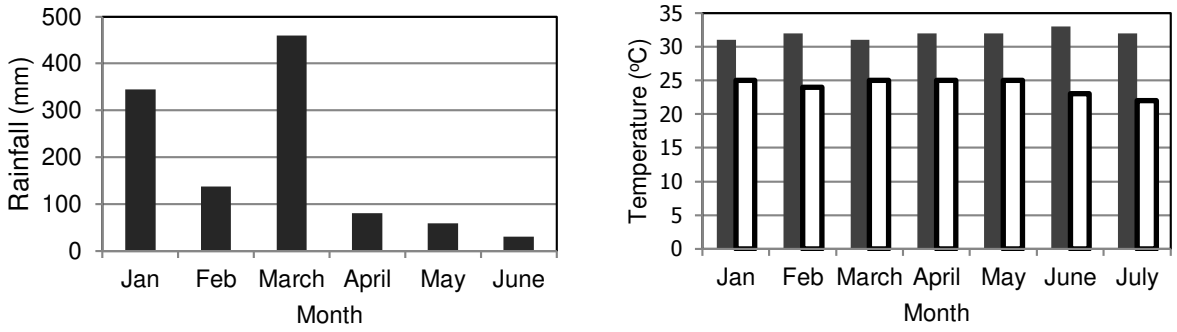

Figure 1. Rainfall, maximum and minimum temperature at Muneng site during trial implementation

RESULTS AND DISCUSSION

Climatic Condition

Rainfall during the emergence and early growth was very high (306 mm), and declined to 80 mm on April and 56 mm on May. Total rainfall at trial site during crop growth (63 DAP) was 442 mm (Figure 1), in the range of optimum in crop rain for mungbean (300-500 mm). There was no water stress during crop growh. The average maximum (31-32ºC) and minimum (25ºC) temperature was relatively constant (Figure 1), and in the range of optimum for mungbean growth (27-30ºC). Total of heat unit of five genotype evaluated from sowing to harvesting was about 1,140 degree days (base temperature 10ºC).

Soil Fertility

Fertilization treatment (L2) improved soil fertility in the topsoil (0-20 cm) as indicated by the increasing of soil pH by 0.1 unit, C-organic by 20%, and N, P, K content consecutively by 17%, 68% and 166% compared with check (L1) (Table 2). Soil fertility in the subsoil (20-40 cm) did not change that indicated no nutrient downward movement from the topsoil. The result showed that fertilization treatment generated different soil fertility condition as expected.

Growth Parameter

Plant height, chlorophyll content index (CCI), number of trifoliate leaf per plant (LN), leaf area per plant (LA) and total dry matter per plant (TDM) significantly affected by fertilization, plant population and genotype treatment, but no significant interaction effect among the three factors. Plant height, CCI, LN and LA were higher on fertilized plot (L2) than on check (L1). Fertilization increased plant height by 8-13%, CCI by 1-6%, LN by 14-16% (Table 3). The result indicated that characters expression of genotipe tested differ at different soil fertility, and they were well expressed when grow on better soil fertility.

Plant height increases as plant population increases, but CCI, LN, LA and TDM reduce. Plant grows tallest at population of 500,000 plants ha^{-1} and the shortest at 200,000 plants ha^{-1}. Plant height increase up to 45 DAP (pod filling stage) and then relatively constant up to harvesting time (Figure 2). CCI decreases as plant population increases. The highest CCI and LA recorded on mungbean genotypes grow on plant population of 200,000 plants ha^{-1} and the lowest one on population of 500,000 plants ha^{-1} (Table 3).

Table 3. Effect of fertilizer and plant population on plant height, chlorophyll content index, number of leaf, and leaf area of mungbean

Treatment	Plant height (cm)			Chlorophyll content index		Number of trifoliate leaf/plant		Leaf area at 45 DAP(cm^2 $plant^{-1}$)
	35 DAP	45 DAP	Harvest	35 DAP	45 DAP	35 DAP	45 DAP	
Fertilization[1)]								
L1	44.4 a	74.5 a	75.3 a	41.34 a	44.92 a	6 a	7 a	332 a
L2	50.3 b	80.9 b	85.7 b	41.90 a	47.51 b	7 b	8 b	432 b
Plant population (plant ha^{-1})								
200,000	42.6 c	73.2 b	77.7 b	42.58 a	46.90 a	8 a	10 a	453 a
333,333	46.8 b	79.0 a	81.1 a	41.41 b	46.50 a	7 b	8 b	359 b
500,000	52.7 a	80.8 a	82.7 a	40.87 b	45.25 b	6 b	6 c	334 b
CV (%)	2.15	3.69	2.67	0.91	0.59	1.0	0.7	79

Remarks: Numbers in one column in each variable with the same letter means not significantly different according to LSD test at 5% level ; [1)]L1= no fertilization; L2= fertilizer rate 37.5 kg N ha^{-1} + 73.5 kg $P_2O_5ha^{-1}$ + 37.5 kg K_2O ha^{-1} + 5 t ha^{-1} Petroganik

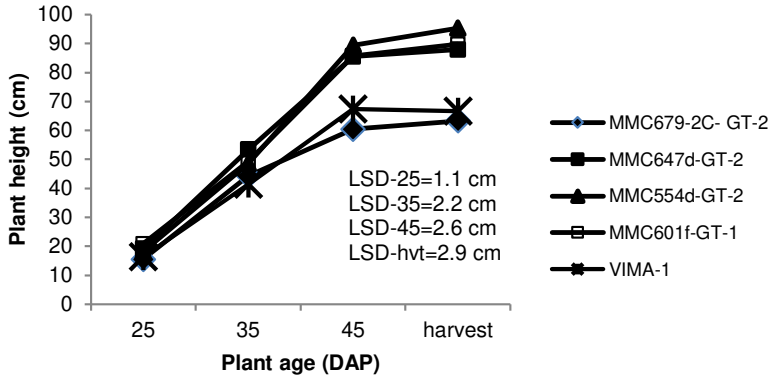

Figure 2. Plant height of five mungbean genotypes at various plant age

The result indicates that the increasing plant population increases the degree of competition among individual plant in acquiring light, water and nutrient for the growth. Mungbean growth showed etiolation on population of 333,333 plants ha^{-1} and 500,000 plants ha^{-1} due to canopy over lapping, so that reduces sunlight interception to the leaf. Shadding condition triggers plant to produce more auxin and other growth regulator that stimulate stem elongation (Taiz & Zeiger, 1991). The result is in accordance with Hamzah, Rosmimi, & Syamsuardi (2005) and S. P. Singh, Sandhu, Dhaliwal, & Singh (2012). Reducing LN and LA on hight plant population decrease capacity of plant to absorb water and nutrients, so that inhibit plant growth and reducing yield. Yield reduction in high plant population related to the reduction in yield component due to high nutrient absorbtion competition (Reddy & Reddy, 2006).

Plant height, LN and LA among mungbean genotypes tested are significantly different at various observation dates, except LN and LA variable at 25 DAP. LN increase in small number up to 45 DAP, but LA reduce after 35 DAP (Figure 3) because some small leaf rise and large older leaf become senescence, means that genotypes tested has maximum LA at 35 DAP. Vima-1 and MMC679-2C-GT-2 grow shorter than the other three genotypes (Figure 2), but LA of Vima-1 is larger than the other genotypes. In contrast with MMC679-2C-GT-2 that grow as high as Vima-1, but with lowest LA. The result indicates that potential source of photosynthesis organ of Vima-1 is the highest, and MMC679-2C-GT-2 is the lowest.

Total biomass accumulation (TDM) on different genotype and plant population is significantly different at all observation date (Figure 3). TDM of five genotypes tested have similar pattern, it grows slower untill 35 DAP and then grow faster as crop start to flowering and pod setting. Fifty percent of MMC679-2C-GT-2 start to flowering at 29 DAP, MMC647d-GT-2 and Vima-1 at 32 DAP, MMC554d-GT-2 and MMC601f-GT-1 at 34 DAP. MMC601f-GT-1 accumulate TDM faster and MMC679-2C-GT-2 slower then the other three genotypes. On fertilizer treated plot, TDM increased by 31-54% during active vegetative stage (25-35 DAP) and 21-25% during generative stage. TDM of MMC601f-GT-1 and MMC554d-GT-2 is the highest, and in contrast for MMC679-2C-GT-2. MMC554d-GT-2, MMC601f-GT-1 and Vima-1 have more LA, LN and TDM then the other two genotypes that indicate have better photosynthesis ability, so that they might have high potential yield. Crops with high LA index will produce high TDM (Khan & Khalil, 2010), and high TDM accumulation is one of high potential yield characteristic of mungbean genotype (Mondal, Hakim, Juraimi, Azad, & Karim, 2011).

TDM accumulation at vegetative as well as generative stages decreases as plant population increases. The highest TDM is recorded at plant population of 200,000 ha plants ha^{-1} and the lowest at 500,000 plant ha^{-1} (Figure 4). TDM accumulation decreases by 30% at population 500,000 plants ha^{-1} that indicates unfavourable condition for optimum growth. Reducing TDM percentage is in accordance with growth stage that indicates increasing interplant competition in accuiring growth resources.

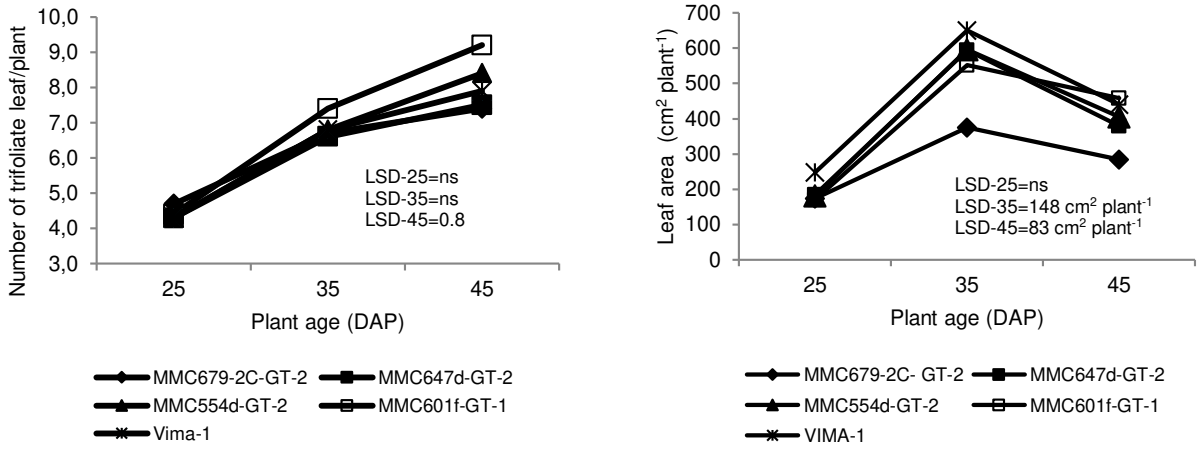

Figure 3. Number of trifoliate leaf (LN) and leaf area (LA) of five mungbean genotypes at various plant age

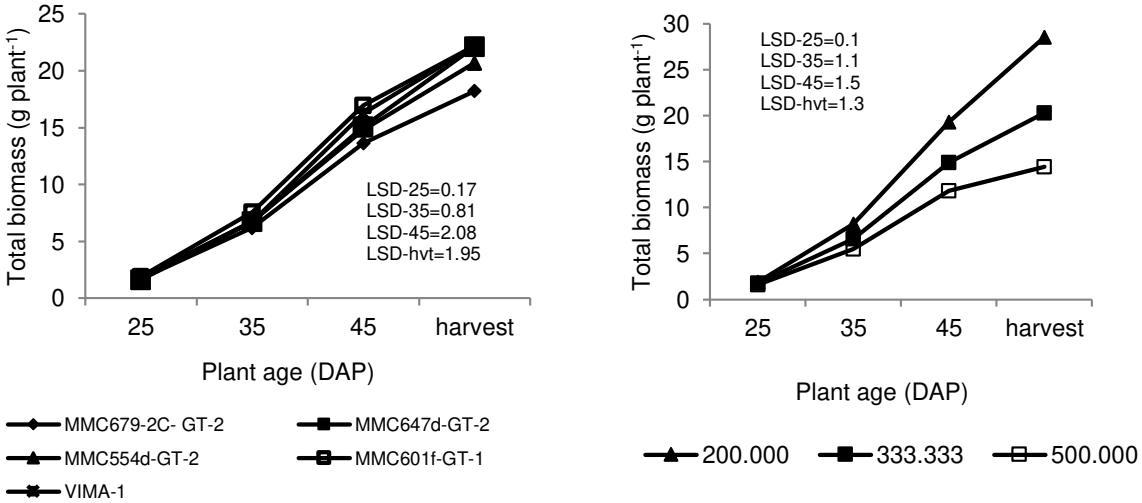

Figure 4. Total biomass (TDM) accumulation at different mungbean genotypes and plant population densities

Table 4. Biomass partitioning of five mungbean genotypes at various plant age

Genotype	Biomass partition (%)									
	25 DAP		35 DAP		45 DAP			At harvest		
	Leaf	Stem	Leaf	Stem	Leaf	Stem	Pods	Leaf	Stem	Pods
1. MMC679-2C-GT-2	65	35	53	47	35	35	30	15	30	55
2. MMC647d-GT-2	63	37	54	46	39	46	15	17	32	51
3. MMC554d-GT-2	64	36	55	45	45	48	7	13	32	55
4. MMC601f-GT-1	63	37	54	46	45	44	11	16	33	51
5. Vima-1	65	35	55	45	42	40	18	14	26	60

Table 5. Relative growth rate (RGR) and nett assimilation rate (NAR) of genotypes tested

Genotype	RGR (g plant^{-1} day^{-1})			NAR (g cm^{-2} day^{-1})	
	25-35 DAP	35-45 DAP	45-60 DAP	25-35 DAP	35-45 DAP
1. MMC679-2C-GT-2	0.13	0.08	0.02	0.04	-0.02
2. MMC647d-GT-2	0.14	0.08	0.03	0.05	-0.02
3. MMC554d-GT-2	0.13	0.08	0.02	0.06	-0.03
4. MMC601f-GT-1	0.14	0.08	0.02	0.07	-0.02
5. Vima-1	0.13	0.09	0.02	0.03	-0.01

Biomass partitioning of genotypes tested more accumulate to leaf during vegetative stage (35 DAP), to leaf and stem in similar amount during pods setting (45 DAP) and to pods during pod fiiling stage up to harvest (Table 4). Pods biomass percentage of MMC679-2C-GT-2 at 45 DAP is higher than the other genotypes that indicates pods development is faster due to earlier flowering date. Vima-1 has the highest pods biomass percentage at harvest that indicates high photosynthesis efficiency.

Relative growth rate (RGR) and nett assimilation rate (NAR) of genotypes tested have similar pattern. RGR is a parameter to indicate the ability of crop to produce dry matter at certain time. NAR is a parameter to indicate the ability of crop to produce dry matter per unit area of leaf at certain time. RGR and NAR increase during vegetative stage and tend to decline up to harvesting date (Table 5).This result indicates that maximum growth rate occurred during vegetative stage and then declines rapidly at pod filling stage until harvest. NAR also increased untill the end of vegetative stage (35 DAP) and then reduced due to increasing effect of interplant shadding. NAR of genotypes tested have negative value during period of flowering to pods setting (35-45 DAP), and plant in this period need more energy through respiration process. LPR of MMC647d-GT-2 and MMC554d-GT-2 genotypes is 8% higher than the other three genotypes at 25 DAP to 35 DAP, but LPR Vima-1 is 13% higher than the other genotypes at 35 DAP to 45 DAP and therefore Vima-1 has smallest negative value of NAR in the same periode.

Grain Yield and Yield Component

Plant population, genotype and fertilization significantly affected number of branches and filled pods, dry weight of pods and grain, and harvest index. Significant interaction effect only observed between population and fertilization to number of branches and filled pods (Tabel 6). Plants have more branches and pods on a more fertile environment as result of fertilization treatment in all plant populations tested, except the number of branches in the treatment population of 500,000 plants ha^{-1}. The increasing plant populations decreases the number of branches and pods on both fertilized or without fertilizer treatment (Table 6). Number of pods at 333,333 and 500,000 plants ha^{-1} respectively decreased by 29% and 47% compared to the population of 200,000 plants ha^{-1}. This suggests that the effect of plant population greater than fertilization.

Weight of pods and seeds per plant decreases by 29% and 50% as plant population increases from 200,000 plants ha^{-1} to 333,000 and 500,000 plants ha^{-1}, respectively (Table 7). Although the yield results components of individual plant falls down due to an increase in plant population up to 500,000 plants ha^{-1}, but the productivity of grain yield per unit area is not significantly different.

Although the yield components results of individual plant falls down due to an increase in

plant population up to 500,000 plants ha^{-1}, but the productivity of grain yield per unit area is not significantly different because it compensates by number of plants. These results showed that all genotypes can be planted in the population of 200,000 to 333,333 plants ha^{-1}.

Table 6. Effect of plant population on number of branches and filled pods of mungbean

Population (plant ha^{-1})	Number of branches plant^{-1}		Number of filled pods plant^{-1}	
	L1[1)]	L2	L1	L2
200,000	1.1 b	1.8 a	17 b	21 a
333,333	0.2 d	0.5 c	12d (29)[2)]	15 c (29)
500,000	0.0 d	0.1 d	9 f (47)	11 e (48)
CV (%)	0.3		1	

Remarks: Numbers in one coloum in each variable with the same letter means not significantly different according to LSD test at 5% level; [1)]L1= no fertilization; L2= fertilizer rate 37.5 kg N ha^{-1} + 73.5 kg P_2O_5ha^{-1} + 37.5 kg K_2O ha^{-1} + 5 t ha^{-1}Petroganik; [2)]number in the brackets is percentage to population treatment of 200,000 plants ha^{-1}

Table 7. Effect of fertilization and plant population on yield and yield components of mungbean

Treatment	Weight of dry filled pods (g plant^{-1})	Weight of dry grain (g plant^{-1})	Weight of dry grain m.c 12% (g plant^{-1})	Harvest index
Fertilization[1)]				
L1	10.5 a	7.2 a	2.4 a	0.38 a
L2	12.1 b	8.1 b	2.3 a	0.34 b
Plant population (plant ha^{-1})				
200,000	15.7 a	10.5 a	2.3 a	0.37 a
333,333	11.0 b (30)[1)]	7.5 b (29)	2.5 a	0.37 a
500,000	7.3 c (54)	5.0 c (52)	2.3 a	0.35 b
CV (%)	0.8	0.6	12.1	0.02

Remarks: Numbers in one column in each variable and each treatment with the same letter means not significantly different according to LSD test at 5% level; [1)] L1= no fertilization; L2= fertilizer rate 37.5 kg N ha^{-1} + 73.5 kg P_2O_5 ha^{-1} + 37.5 kg K_2O ha^{-1} + 5 t ha^{-1} Petroganik; [2)] number in the brackets is percentage to population treatment of 200,000 plants ha^{-1}

Table 8. Yield and yield component of mungbean genotypes tested

Genotypes	Number of branches per plant	Number of filled pods per plant	Weight of dry filled pods (g plant^{-1})	Weight of dry grain (g plant^{-1})	Weight of dry grain m.c 12% (g plant^{-1})	Harvest index
1. MMC679-2C-GT-2	0.5 b	14 a	9.8 c	6.7 c	2.2 c	0.37 ab
2. MMC647d-GT-2	0.4 b	14 a	11.3 b	7.6 b	2.3 bc	0.34 c
3. MMC554d-GT-2	0.6 b	14 a	11.3 b	7.5 bc	2.5 a	0.37 ab
4. MMC601f-GT-1	0.5 b	13 a	11.1 b	7.8 ab	2.4 ab	0.35 bc
5. Vima-1	1.0 a	15 a	13.1 a	8.6 a	2.4 ab	0.39 a

Remarks: Numbers in one column in each variable with the same letter means not significantly different according to LSD test at 5% level

Table 9. N, P and K uptake on mungbean genotype at the end of vegetatif stage (35 DAP)

Fertilization[1)]	Uptake in the leaf (mg plant^{-1})			Uptake in the stem (mg plant^{-1})		
	N	P	K	N	P	K
L1	143.4	12.6	78.7	40.2	8.2	101.2
L2	191.1	16.6	96.6	59.0	10.5	157.4

Remarks: [1)] L1= no fertilization; L2= fertilizer rate 37.5 kg N ha^{-1} + 73.5 kg P_2O_5ha^{-1} + 37.5 kg K_2O ha^{-1} + 5 t ha^{-1} Petroganik

Table 10. N, P and K content in the leaf and stem of mungbean at the end of vegetatif stage (35 DAP) at different fertilization and plant population treatments

Population (plants ha^{-1})	Nutrient content (%)											
	Leaf						Stem					
	N		P		K		N		P		K	
	L1[1)]	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
200,000	4.48	4.68	0.40	0.41	2.64	2.32	1.53	1.75	0.30	0.32	3.72	4.77
333,333	4.63	4.63	0.39	0.40	2.25	2.28	1.55	1.64	0.32	0.29	4.13	4.05
500,000	4.24	4.49	0.38	0.39	2.41	2.42	1.33	1.55	0.29	0.28	3.32	4.39
Average	4.45	4.60	0.39	0.40	2.43	2.34	1.47	1.65	0.30	0.29	3.72	4.40

Remarks: [1)] L1= no fertilization; L2= fertilizer rate 37.5 kg N ha^{-1} + 73.5 kg P_2O_5 ha^{-1} + 37.5 kg K_2O ha^{-1} + 5 t ha^{-1} Petroganik

Grain yield and yield components are significantly different among genotypes, except number of filled pods (Table 8). Grain yield of MMC554d-GT-2, MMC601f-GT-1 and Vima-1 is significantly higher than MMC679-2C-GT-2 and MMC647d-GT-2. The higher grain yield of MMC554d-GT-2 and Vima-1 probably related to high effectiveness and efficiency of photo-synthesis as indicated by higher LN, LA and biomass partition to the seed. The higher grain yield of MMC601f-GT-1 probably related to bigger seed size. Vima-1 has the highest harvest index (HI) that indicates high photosynthesis efficiency. The result showed that genotype with high TDM accumulation and LA tends to have high yield, and this is in accordance with Ahmed, Hirota, Yamada, & Rahman (2003), Sharma-Natu & Ghildiyal (2005), Mondal, Fakir, Islam, & Samad (2011), Malek, Mondal, Ismail, Rafii, & Berahim (2012). HI of all genotypes tested ranged from 0.34 to 0.39, and this is little bit higher than that reported by Thomas, Robertson, Fukai, & Peoples (2004) which is 0.3.

Nitrogen, Phosphorous and Potassium Uptake

Fertilization treatment increases nitrogen (N), phosphorous (P) and potassium (K) uptake in the leaf and stem. N, P and K uptake in the leaf at the end of vegetatif stage (35 DAP) increased by 33%, 32% and 23%, respectively, while in the stem increased consecutively 47%, 29% and 56% compared with that of no fertilization (Table 9). As much as 77% of N and 62% of P are accumulated in the leaf, while 61% of K accumulated in the stem (Table 10). Higher N accumulation in the leaf may be related to the function as part of chlorophyl component. Nitrogen is the main constituent element of amino acids and lipids forming the chloroplast, and element of rubisco enzyme (25-30% of total N) that has important role in photorespiration (Ouda & Mahadeen, 2008). Higher K accumulation in the stem may be related to the role in nutrient and assimilate translocation.

Content of N, P and K in the leaf and stem decreases as plant population increased, and the lowest is at population of 500,000 plant ha^{-1} (Tabel 10). The result indicates that competition in acquiring N, P and K nutrient increases as plant population increases. Fertilization treatment increased N, P and K content in the soil, and it seems reducing the competition as indicated by higher nutrient content at fertilization treatment compare to no fertilization.

CONCLUSION

Five genotypes tested have the same respons to an increase in soil fertility which grew higher, had more leaf number, leaf area, biomass accumulation, chlorophyll content, number of pods and seed weight. The increasing plant population from 200,000 plant ha^{-1} to 333,333 plants ha^{-1} and

500.000 plants ha^{-1} induced crops grow taller, but reduced number of leaf, leaf area, chlorophyll content, and biomass accumulation due to the increasing interplant competition for light and nutrients. Increasing nutrient competition at high plant population could be minimized by fertilization. Number of pods and seed weight reduced by 30% every 50-60% of population increased, even though grain yield productivity was not affected by compensation between yield component and plant population. The five genotypes tested are suitable planted on population of 200,000 and 333,333 plants ha^{-1}. With proper fertilization and population management, the genetic potential can be expressed as follow 3.5 t ha^{-1} for MMC554d-GT-2, 2.4 t ha^{-1} for MMC601f-GT-1 and Vima-1, 2.2 t ha^{-1} for MMC679-2C-GT-2 and 2.3 t ha^{-1} for MMC647d-GT-2.

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