Academic Journal of Plant Sciences 12 (1): 01-07, 2019
ISSN 1995-8986

DOI: 10.5829/idosi.ajps.2019.12.1.01.07

Some Agronomic Studies on Mungbean (*Vigna radiata* (L.) WILCZEK) Genotypes

[1]E.M. Abd El-Lateef, [1]M.S. Abd El-Salam, [1]T.A. Elewa, [1]A.A. Farrag and [2]R.T. Behairy

[1]Field Crops Research Dept., Agricultural Division,
National Research Centre, 33 El-Behooth St., Giza, Egypt
[2]Seed Technology Res. Dept., Field Crop Res., Inst., Agric. Res. Cent., Giza, Egypt

Abstract: Six mungbean genotypes divided to two sets viz; three small seed size (100 seeds < 5 g) Kawmy-1 (the only registered variety in Egypt), M 53 and T 44 were compared versus other three large seeds size (100 seeds > 5 g) V 2010, VC l000 and VC 2719 genotypes in field experiments in the to study the performance of different genotypes with different seed size on mungbean yield and yield components. The obtained results showed that small seed size genotypes significantly exceeded the large ones in branching, no of pods, seed yield plant^{-1} seed yield per hectare and protein yield while large seeds genotypes surpassed the small ones in plant height, seed index and harvest index, biological and straw yields. Mungbean genotypes reached 50% flowering within 40 to 46 days and Kawmy-1 was the earliest variety in flowering. Significant differences in mungbean plant height and number of branches plant^{-1} were recorded. The greatest number of pods plant^{-1} was recorded by M 53 and Kawmy-1, while the lowest was recorded by V2010. The data also showed that although V 2010 recorded the highest 1000-seeds weight, it possessed the highest pod-shuttering percent (>25%). Kawmy-1 variety gave the highest harvest index value, seed yield per plant and per hectare. In general, mungbean seed yield ranged between 1713 and 3759 kg ha^{-1}. All the tested genotypes gave more than 50% of the total seed yield at the first harvest (80 days after sowing) reflecting the fact that they are early maturing. The greatest biological yield ha^{-1} was recorded by large seed genotypes V 2010, VC 1000 and VC 2719 as well as the small seed one T44. The lowest biological yield ha^{-1} was recorded for M53 variety. Except for T44, the other four mungbean genotypes gave similar yields more than 2 t ha^{-1}. without significant differences. Protein percentage in mungbean seeds ranged from 387 and 644 kg ha^{-1} for T 44 and Kawmy-1 variety, respectively. lt could be concluded from this study that Kawmy-1 is the highest yielding variety, also VC I000, M 53 and VC 2719 are early maturing and promising high yielding genotypes. Large seed genotypes with high yield potentiality are favored.

Key words: Mungbean · Genotype · Seed size · Yield

INTRODUCTION

Pulses are known as poor man's meat and cheap source of vegetable protein containing 20-25% protein. The mungbean (*Vigna radiata* (L.) Wilczek) is esteemed among the entire pulse species because it is an easily digestible pulse, [1]. In the last decades, mungbean has been introduced to the Egyptian agriculture as a promising crop [2]. It is a short duration legume crop with low water requirements, [3] with high nutritive value and known in both southern parts of Asia and Africa for human consumption [4]. One of the common problems is the production of mungbean still remain static during the last decade; and requires development especially in the production centers like Pakistan, [1]. Several advantages are evident for mungbean which candidate this crop for rapid wide spreading under Egyptian conditions. It has high nutritive value and due to this, has advantage over the other pulses. The seed contains 20-24% protein content, 1.30 % fat and 60.4 % carbohydrates; calcium (Ca) is 118 and phosphorus (P) is 340 mg per 100 g of seed, respectively, [1]. Also, it fixes atmospheric nitrogen through Rhizobium species. Several researches have been continued to introduce and explore the most proper agronomic practices which maximize the productivity of mungbean under Egyptian conditions [2, 5-9].

Corresponding Author: Abd El Lateef, Field Crops Research Dept., Agricultural Division, National Research Centre, 33 El-Behooth St., Giza, Egypt.

Mungbean genotypes have a wide range of variability in growth and yield according to the environmental conditions [10]. In Egypt, the effect of mungbean varietal differences on yield was evident at the same location [2, 11] as well as when the same variety was grown in different environments [5]. Therefore, the evaluation of mungbean genotypes in a specific location is necessary for mungbean adaptation, Imrie and Lawn [10] pointed out that the success or failure of a newly introduced crop will depend on the availability of well adapted cultivars. Moreover, from the experience under Egyptian conditions, the Egyptian farmer do not prefer the small seed varieties (test weight < 5 gm/100 seeds) but he prefers the large seed ones and this is considered an important factor for wide spreading this crop. Seed size is a polygenic trait with high heritability (> 80%) [12-14].

It was found that large seed size significantly increased seedling survival as compared to small seed size by 25%. The use of differing seed size physical parameters as discriminating criteria for seed among varieties and different species has been previously reported demonstrating that the there is an association between seed parameters and seed quality, Mirshekarnezhad *et al*. [15]. On contrast, Mondal *et al*. [16, 17] observed that seed yield of mungbean had no positive relation with pod and seed size as well as harvest index.

The objective of this study is to evaluate the differences of small and large seed of some promising mungbean genotypes (*Vigna radiate* (L.) *Wilczek*) on yield and yield component traits under Egyptian conditions.

MATERIALS AND METHODS

Two field experiments were carried out in 2016 and 2017 summer seasons in the Agricultural Experimental Station of the National Research Centre, Behairah Governorate. Two sets of mungbean genotypes *viz*., small seed genotypes 100 seeds < 5 g and large seed genotypes 100 seeds > 5 g were compared in the trials. Three small seed genotypes were used in the experiment namely Kawmy-1*, M 53 and T 44 and other three large seed genotypes were V 2010, VC 1000 and VC 2719. The experimental soil was sandy in texture with pH 7.8, OM. 1.28%, N 0.47%, P 0.48% and K 0.27%. The soil was ploughed twice, ridged and divided to experimental plots each of 50 m^2 (1/200 ha). The experimental design was in Complete Randomized Blocks with four replicates. A uniform basal dressing of phosphatic fertilizer as calcium super phosphate (15.5% $P_2 0_5$) at a rate of 360 kg ha^{-1} was applied during seed-bed preparation. Mungbean seeds were inoculated with the specific *Rhizobium* strain and immediately sown in hills (15 cm apart on both sides of the ridge. Sowing dates were 27 and 30 May in 2016 and 2017, respectively. A starter dose of 36 kg N ha^{-1} was applied at sowing as ammonium nitrate (33.5% N). Two weeks later the plants were thinned at two plants per hill to attain the usual field number of plants (446 x 10^3 plants ha^{-1}). Weeds were controlled manually at 14 and 32 days after sowing. Irrigation took place every week until 80 days, then it was stopped. During the growing season two ridges were labeled and the number of days to 50% flowering was recorded. Harvest was carried out twice after 80 and 100 days from sowing. At the second harvest, four guarded hills (8 plants) were labeled and the following parameters were registered:

- Plant height (cm).
- Number of branches $plant^{-1}$.

Yield components traits:

- Number of pods $plant^{-1}$.
- Number of shuttered pods $plant^{-1}$.
- Number of seeds pod^{-1}.
- 1000-seeds weight (g).
- Seed yield per plant (g).
- Harvest index.

Yield: Two ridges were devoted for pod collecting twice at 80 and 100 days to determine seed yield per hectare in each of the two harvest times as well as the total seed yield (kg ha^{-1}). Total crude protein percentage was determined in mungbean seeds for all genotypes according to A.O.A.C. [18].

Statistical Analysis: The data of both seasons were subjected to the statistical analysis of the randomized complete block design using MSTAT-C Computer Software [19] after testing the homogeneity of the error according to Bartlett's test, combined analysis for both seasons were done. Means of the different treatments were compared using the least significant difference (LSD) test at P<0.05. Seed size comparison was statistically adopted using t test and treatment means were compared using least significant differences test (LSD) at 5% probability level according to Gomez and Gomez [20].

RESULTS AND DISCUSSION

Effect of Seed Size on Mungbean Characters: Data presented in Tables (1 and 2) show the effect of mungbean seed size regardless the genotypes on yield characters (combined data of 2016 and 2017 seasons). Generally, small seed size genotypes significantly exceeded the large ones in branching, no. of pods, seed yield plant^{-1} seed yield ha^{-1} after 100 days and protein yield while large seeds genotypes surpassed the small ones in plant height, seed index, harvest index and biological and straw yields. The superiority of the small seed genotypes in crude protein percentage could be attributed to the dilution effect where crude protein distributes in smaller mass than the large seeds genotypes which possesses greater mass, therefore it affects crude protein percentage. The obtained results are logic and agree with Hoy and Gamble [21]; Sexton *et al*. [22], they stated that small seeds of soybean and common bean perform better than large seeds due to seedling from small seeds were less damaged than large seeds, while the large seeds of winter wheat [23] and mungbean [24] under the same conditions tended to do better in germination. However, seed size has been considered to be asignificant factor only during the early stage of plant growth, nevertheless, Amin [24] reported that 50% of large-seeded mung bean matured earlier than that of small-seeded type. Despite large seed has an advantage of having higher stored energy supply but not all reports demonstrate the effects of seed size on the yield. Rezapour. *et al*. [25] reported in soybean that the large seeds harvest index was 11.94% higher than small seeds Mirshekarnezhad *et al*. [15] showed that cultivars were with large seeds have the highest seedling emergence rate, 1000-seeds weight and seed yield were superior to control.

Effect of Genotype

Number of Days to 50% Flowering: Data presented in Table (3) show that mungbean genotypes reached 50% flowering during a period of 40.5 - 45 days after sowing. Kawmy-1 and T 44 were the earliest ones in flowering followed by VC 1000 and M 53 without significant differences. However, the latest genotypes were VC 2719 and V 2010. Kawmy-l variety significantly surpassed the other genotypes in this phenomenon (40.5 days after sowing) and the rest of the genotypes reached 50% flowering after a period that ranged between 43 and 45 days after sowing. This relatively short period to flowering was attributed mainly to the effect of day length since mungbean plants under the summer planting are sensitive to such environmental factor. Abd El Lateef *et al*. [11] found that different mungbean accessions gave their first flower after a period of 43 to 45 days and from 44.3 to 46.3 in two successive seasons in Egypt.

Table 1: Effect of mungbean seed size on yield characters (Combined data 2016 and 2017 seasons).

Mungbean seed size	No. of days to 50% flowering	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1} Shattered	Complete	Total	No. of seeds pod^{-1}	1000 seeds weight (g)	Seed yield plant^{-1} (g)	Harvest index
Small seeds	42.7	65.9	5.8	0	39.8	39.8	8.2	36.3	7.6	0.24
Large seeds	43.8	87.2	10.1	2.1	27.6	29.7	9.3	59.9	3.9	0.21
Significance P<0.05	NS	**	**	*	**	**	NS	**	**	NS

Table 2: Effect of mungbean seed size on biological, straw, seed and protein yields (Combined data 2016 and 2017 seasons)

Mungbean seed size	Biological yield ha^{-1} (ton)	Straw yield ha^{-1} (ton)	Seed yield ha^{-1} (kg) 80 days	100 days	Total	Crude Protein %	Protein yield ha^{-1} (kg)
Small seeds	12.14	9.88	1357	900	2257	22.9	519.5
Large seeds	13.89	11.81	1314	772	2086	21.5	448.5
Significance P<0.05	*	*	*	*	**	*	*

Table 3: Effect of mungbean genotype on yield components (Combined data 2016 and 2017 seasons)

Variety	No. of days to 50% flowering	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1} Shattered	Complete	Total	Seeds pod^{-1}	1000-seeds weight (g)	Seed yield plant^{-1} (g)	Harvest index
Kawmy-I	40.5	75.5	5.05	0	39.1	39.1	10.1	41.5	9.34	0.26
M 53	44.5	73.8	6.25	0	41.2	41.2	4.9	24.9	7.24	0.24
T 44	43.0	83.6	6	0	39	39	9.6	42.5	6.195	0.23
V 2010	43.5	91.3	4.25	5.7	14.9	20.6	9.1	64.75	5.675	0.20
VC 1000	43.0	88.4	2.65	0	31.5	31.5	9.5	56.15	7.35	0.22
VC 2719	45.0	81.9	4.4	0.6	36.3	36.9	9.4	58.9	5.975	0.22
LSD at 0.05	1.85	8.2	1.65	0.5	2.5	2.7	ns	3.25	1.35	ns

Table 4: Effect of mungbean genotype on yield characters and protein yield (Combined data 2016 and 2017 seasons)

Variety	Biological yield ha^{-1} (ton)	Straw yield ha^{-1} (ton)	Seed yield ha^{-1} (kg) 80 days	100 days	Total	Crude Protein %	Protein yield ha^{-1} (kg)
Kawmy-I	12.30	9.54	1569	1190	2759	23.5	648.4
M53	11.60	9.3	1377	924	2301	23.1	531.5
T44	12.53	10.82	1126	587	1713	22.1	378.6
V2010	14.21	12.32	1279	611	1890	21.2	400.7
VC1000	13.46	11.18	1411	871	2282	21.7	495.2
VC2719	14.01	11.92	1251	834	2085	21.7	452.5
LSD at 0.05	1.17	0.76	233.01	180	423	0.72	57.6

Shalaby *et al*. [26] found that different mungbean accessions gave their first flower after a period of 45 to 55 days and from 44.3 to 56.3 days in two successive seasons in upper Egypt. The obtained results are in accordance with the results obtained by other researchers for most of the legumes [27-30]. They stated that grain yield had positive significant correlation with plant height, number of branches and pods $plant^{-1}$, 1000 grain weight and biological yield.

Plant height and number of branches $plant^{-1}$: Data given in Table (3) show that mungbean plant height ranged between 73.8 cm for M53 and 88.4 cm for VC 1000, M 53 and Kawmy-l were the shortest genotypes, whereas the tallest was V2010. Significant effects concerning mungbean genotypic differences were reported on number of branches $plant^{-1}$. The greatest number of branches $plant^{-1}$ was recorded for M 53 and T 44 genotypes while the lowest was recorded by VC 1000, V 2010 and VC 2719. The variability in mungbean plant height and number of branches in the different accessions was reported under Egyptian conditions for the Pakistani genotypes [2]. Some investigators tried to find the relationship of mungbean plant height and seed yield and reported that seed yield positively correlated with plant height [31]. However, other investigators reported a negative correlation between plant height and seed yield [32] indicated that this relation is inconsistent where genotype with taller plants may not always demonstrate higher yield. Shamsuzzaman *et al*. [33] found that plant height was strongly associated with main branches per plant and pods per plant.

Yield Components

Number of Pods $Plant^{-1}$ and Number of Seeds Pod^{-1}: From Table (3) it is clear that M 53 gave the greatest number of pods $plant^{-1}$. However, the lowest number of pods $plant^{-1}$ was recorded by V 2010 genotype, as compared with the other genotypes. Kawmy-l possessed the greatest number of seeds per pod while the lowest number was recorded for the genotype V 2010. The data of pod-shuttering revealed that five genotypes were tolerant to shuttering, namely Kawmy-l, VC 1000, M 53 and T 44 and VC 2719. However, V 2010 genotype was the most shuttering one where the shuttered pods reached > 25% from the total number of pods formed per plant.

1000- Seeds Weight: Data given in Tables (3) also show significant differences among mungbean genotypes in 1000-seeds weight. It can be realized that V 2010 significantly surpassed the other large seeds genotypes while T 44 recorded the greatest seed weight in the small seed genotypes. Mungbean yield traits of number of pods $plant^{-1}$, number of seeds/pod and 1000-seeds weight is considered to be the most important yield determinates of mungbean. Several investigators emphasized the importance of the phenotypic selection for such traits though these characters are highly heritable. Seed yield is associated with many other traits, such as number of pods $plant^{-1}$and seeds pod^{-1} [34]. Seed yield was reported to be positively correlated with plant height [31]. However, a negative correlation was also reported [32]. In Egypt, Shalaby *et al*. [26] and the studies of Ashour *et al*. [5] come to similar conclusion.

Seed Yield per Plant: Data presented in Table (3) show significant differences in seed yield $plant^{-1}$ among mungbean genotypes. Kawmy-l significantly surpassed the other genotypes in seed yield $plant^{-1}$ while the genotypes VC 1000, M 53 and VC 2719, T 44 gave similar seed yield without significant differences. The superiority of Kawmy-1 variety in seed yield per plant was attributed to the greatest number of pods with less shuttering per plant. Such magnitude was also true for the genotypes VC 1000 and VC 2719 where shuttering percent was nil. On the contrary V 2010 possessed the greatest pod-shuttering percent and lower number of pods $plant^{-1}$ gave lower seed yield per plant although it has the greatest 1000-seeds weight. Thus, the impact of yield components traits on seed yield per plant should be taken in consideration in mungbean breeding programs.

Harvest Index (HI): Data in Table (3) show insignificant differences in harvest index of mungbean genotypes. The greatest values of HI were reported by Kawmy-l variety M 53 and T 44. In other words, the smaller mungbean seed size genotypes possessed greater HI than that of the large seed ones. Moreover, V 2010 genotype recorded the lowest HI values and such low HI values of V 2010 may be attributed to its greatest shuttering percentage and the lower seed yield per plant compared with the other genotypes. The varietal differences of mungbean in HI have been reported by [25, 31, 35] who reported in soybean that the large seeds harvest index was 11.94% higher than small seeds. Also, Abd El Lateef *et al*. [9] emphasized the impact of 1000-seeds weight on the final yield of mungbean plants.

Yield

Biological and Straw Yields ha^{-1}: Data presented in Table (4) indicate significant differences among mungbean genotypes in the biological yield ha^{-1}. The greatest biological yield ha^{-1} was recorded by large seed genotypes V 2010, VC 1000 and VC 2719 genotype as well as the small seed one T 44. The lowest biological yield ha^{-1} was recorded for M53 variety. From the same table, it can be noticed that straw yield ha^{-1} showed similar tendency to biological yield. Significant differences were reported by mungbean genotypes in straw yield ha^{-1} and the greatest straw yields were recorded by large seed genotypes V 2010, VC 1000 and VC 2719 genotypes as well as the small seed one T 44. On the other hand, Kawmy-l and M 53 recorded the lowest straw yield ha^{-1}. Karadavut [36] pointed out that biological yield could be accepted as the most valuable characteristic among the mungbean traits, due to it had the highest direct effect on grain yield which could be increased via straw yield, branches per plant and pods per peduncle.

Seed Yield per Hectare: Data given in Table (4) clearly show that all mungbean genotypes gave more than 50% of total seed yield in the first harvest (after 80 days). VC 1000 and Kawmy-l gave the highest seed yield per hectare after 80 days followed by M 53. These results mean that the two genotypes are the earlier ones among the different genotypes and these results are parallel to the criteria of (No. of 50% flowering, Table 3). The lowest seed yield per hectare after 80 days from sowing was recorded for the genotype VC2719. The greatest seed yield per hectare in the second harvest (100 days from sowing was recorded by Kawmy-l variety, whereas, the lowest seed yield occurred by V2010 and T 44. With regard to the total seed yield per hectare it is clear that Kawmy-l variety surpassed the other mungbean genotypes followed by VC 1000 and M 53 without significant differences. On the other hand, the lowest yield was recorded by V 2010 and T 44 and except for T 44, the other four mungbean genotypes gave similar yields more than 2 t ha^{-1} without significant differences. The higher productivity of Kawmy-l compared with the other mungbean genotypes in both seasons may be attributed to the greater number of pods plant^{-1} without shuttering, which led to greater seed yield per plant and consequently per hectare. On the other hand, the lower productivity of V 2010 could be attributed to the higher number of shuttered pods than the other genotypes. Such results are in accordance with those obtained by Ashour *et al*. [5] who reported that Kawmy-l variety out yielded V 2010 and VC l000 in seed yield per hectare at over 11 locations in Egypt. Similarly, Poehlman [34] reported that seed yield is associated with many other traits, such as number of pods per plant and seeds per pod and yield variation in mungbean accessions with high grain yield should have sufficient plant height and high number of pods per plant. Also, Lukman [37] studied the Variability of yield related characters among 350 accessions of mungbean and he found that it was significant especially for characters of the days to maturity, plant height pods per plant and seed size and high yielding mungbean genotypes could be obtained by selecting taller or medium plants with high number of pods per plant and medium or small seed size. Also, these findings are in accordance with the results obtained by other researchers for most of the legumes [27-30]. They stated that grain yield had positive significant and positive correlation with plant height, number of branches and pods plant^{-1}, 1000 grain weight and biological yield.

Crude Protein (%) and Protein Yield Ha^{-1} (kg): Data in Table (4) show that mungbean genotypes differed significantly in crude protein percentage. Crude protein percentages in mungbean genotypes ranged between 21.2 and 23.5 %. Kawmy-l and M 53 genotypes contained the highest crude protein percentages in both seasons, whereas, the lowest were reported for VC 2719 and V 2010, respectively. It can be noticed form Table (4) that mungbean genotypes significantly differed in crude protein yield ha^{-1}. Kawmy-l, VC 1000 and M 53 gave the highest crude protein yield ha^{-1}, while Kawmy-l was the most superior variety in crude protein yield ha^{-1}. The lowest crude protein yields were recorded for V 2010 and T 44 genotypes as well as VC 2719. Under Egyptian conditions Farrag [38] reported differences in protein percentage and protein yield ha^{-1} according to the variety. The superiority of the small seed genotypes in crude protein percentage could be attributed to the dilution effect where crude protein distributes in smaller mass than the large seeds genotypes which possesses greater mass, therefore it affects crude protein percentage. Kyei-Boahen *et al*. [39] reported that grain protein concentration of cowpea followed a similar trend as grain yield and ranged from 223 to 252 g kg^{-1} but a negative correlation between grain yield and protein concentration was observed.

CONCLUSION

It could be concluded from this study that Kawmy-l, VC l000, M 53, VC 2719 are early maturing and promising high yielding genotypes. Moreover, Kawmy-l had the highest protein content. Although small seed size genotypes exceeded the large seed yield ha^{-1}, large seed genotypes with high yield potentiality are favored**.**

ACKNOWLEDGEMENT

The authors present this work to the soul of the late Prof Dr. Nabih I. Asour and Prof Dr. Tawdy G. Behairy for their efforts in introducing mungbean to the Egyptian agriculture.

REFERENCES

1. Imran, I., A. Khan, I. Inam and F. Ahmad, 2016. Yield and yield attributes of mungbean (*Vigna radiata* L.) cultivars as affected by phosphorous levels under different tillage systems. Cogent Food and Agriculture, 2: 1151982.
2. Ashour, N.I., T.G. Behairy, M.M. Selim and E.M. Abd EL-Lateef, 1992. Mungbean (*Vigna radiata* Roxb), A new Introduced crop in Egypt. 2 varietal differences in growth and yield. Conf. of Agron., 13-15 September, Zagazig University, pp: 361-370.
3. Abd El Lateef, E.M., 2009. Productivity of some new introduced crop species with low water requirements in Mediterranean region with special reference to Egypt. 15th International Symposium on Environmental Pollution and its Impact on life in the Mediterranean region with focus on Environmental Threats in the Mediterranean region: Problems and Solutions. October 7-11, 2009, Bari, Italy.
4. Lawn, R.J. and C.S. Ahn, 1985. Mungbean (*Vigna radiata* (L.) Wilczek / *Vigna mungo* (L.) Hepper), In " Grain Legume Crops (Eds: R. J. Summerfield and E.H Roberts) Collins, London, pp: 584-623.
5. Ashour, N.I., S. Abou Khadrah, H. Mosalem, M.E. Yakout, G.M. Zedan, M.E. Abd El Lateef, T.G. Behairy, Sh. A. Shaban, A.N. Sharaan, M.M. Selim, S.A. Mahmoud, M.W. Hassan, G.G. Darwish and M.Z. EL-Hifny, 1995. Introduction of mungbean (*Vigna radiata* (L.) Wilczek) in Egypt. 2-Effect of genotype, planting density and location on mungbean yield. Egypt. J. Agron., 20(1): 99-108.
6. EI-Karamany, M.F., Magda H. Mahmoud and O.A. Nofal, 2003. Effect of late foliar application with urea and potassium fertilization on yield, yield components and chemical composition of two mungbean varieties. Egypt. J. Appli. Sci., IS(12): 177-188.
7. Hozayn, M., M.S. Zeidan, E.M. Abd El-Lateef and M.S. Abd El-Salam, 2007. Performance of some mungbean (*Vigna radiata* L. Wilczek) genotypes under late sowing condition in Egypt. Res. J. Agric. and Biol. Sci., 3(6): 972-978.
8. Abd El-Salam M.S.; N.I. Ashour and H.M. Abd El-Ghany, 2008. Forage production in sole and mixed stands of fodder maize (*Zea mays* L.) and mungbean (*Vigna radiata* L. Wilczek). Bull. NRC, Egypt, 33(1): 27-34.
9. Abd El Lateef, E.M., B.A. Bakry, M.S. Abd El-Salam and T.A. Elewa, 2015. Mungbean (*Vigna radiata* L. Wilczek) varietal tolerance to biological stress. Int. J. ChemTech Res., 8(12): 477-487.
10. Imrie, B.C. and R.J. Lawn, 1991. Mung bean: The Australian Experience proc.1st Australian Mung bean workshop, Brisban, pp: 53.
11. Abd El Lateef, E.M., N.I. Ashour and T.G. Behairy, 1998. Effect of varietal differences on mungbean (*Vigna radiata* (L.) Wilczek) yield and yield components. Bull. NRC, 23(3): 367-381.
12. Imrie, B.C., Z.U. Ahmed and J.P.J. Eerens, 1985. Heritability of seed weight in mungbean. SABRAO J. Breed. Genet, 17: 173-175.
13. Humphry, M.E., C.J. Lambrides, S.C. Chapman, E.A.B. Aitken, B.C. Imrie, R.J. Lawn, C.L. MacIntyre and C.J. Liu, 2005. Relationships between hard-seeded-ness and seed weight in mungbean (*Vigna radiata)* assessed by QTL analysis. Plant Breeding, 124: 292-298.

14. Yimram, T., P. Somta and P. Srinives, 2009. Genetic variation in cultivated mungbean germplasm and its implication in breeding for high yield. Field Crops Res., 112(2-3): 260-266.
15. Mirshekarnezhad, B., G. Abbas Akbari, G. Ali Akbari and H. Sadeghi, 2013. Affiliation of seed size with germination aspects and morphological traits in safflower (*Carthamus tinctorius* L.). Journal of Cereals and Oilseeds, 4(5): 58-64.
16. Mondal, M.A., M.A. Hakim, A.S. Juraimi and M.A. Azad. 2011a. Contribution of morpho-physiological attributes in determining yield of mungbean. African Journal of Biotechnology, 10(60): 12897-12904.
17. Mondal, M.A., M.S. Fakir, A.S. Juraimi, M.A. Hakim, M. Islam and A.T. Shamsoddoha, 2011b. Effect of flowering behavior and pod maturity synchrony on yield of mungbean. Australian J. Crop Sci., 5: 945-953.
18. A.O.A.C. 1995. Association of Official Analytical Chemists. Official methods of analysis, 16*th* edition, AOAC International, Washington, DC.
19. MSTAT-C, 1988. MSTAT-C, a microcomputer program for the design, arrangement and analysis of agronomic research. Michigan State University, East Lansing.
20. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research (2nd ed.). John Wiley and Sons, New York, pp: 680.
21. Hoy, D.J. and E.E. Gamble, 1987. Field performance in soybean with seeds of different size and density. Crop sci. 27:121-126. http://www.Australianoilseeds.com/ -data/assets/pdf-file; visited on June 26, 2013.
22. Sexton, P.J., J.W. White and K.J. Boote, 1994. Yield-determining processes in relation to cultivar seed size of common bean. Crop. Sci., 34: 84-91.
23. Chastain, T., G.K.J. Ward and D.J. Wysocki, 1995. Stand establishment responses of soft white wheat to seedbed residue and seed size. Crop Sci., 35: 213-218.
24. Amin, A.D., 1999. Influence of seed size on the performance of mung bean varieties under postrice and upland cropping systems. Asia regional center-AVRDC [online URL:www.arc.avrdc-org/pdf-files/Amin (17-N). pdf] accessed on July 13, 2006.
25. Rezapour, R., H. KazemiArbat and M. Yarnia, 2013. The effect of seed size on yield, harvest index and its correlation to soybean seed vigour. Seed Research. 3(2): 62-73.
26. Shalaby, G.L., H.A. Hussein and M.A. Farghaly, 1991. Study of the performance of some introduced mungbean accessions under Assuit conditions. Assuit J. Agric. Sci., 22: 231-243.
27. Mahmood-ul-Hassan., M. Zubair and S. Ajmal, 2003. Correlation and path coefficient analysis in some promising lines of mash bean (*Vigna mungo*). Pak. J. Biol. Sci., 6(4): 370-372.
28. Achakzai, A.K.K. and S.A. Kayani, 2004. Effect of fertilizer and inoculation on the growth and yield of soybean cv. Williams-82 in pot culture. Pak. J. Agric. Res., 18(1): 83-93.
29. Siddique, M., M.F.A. Malik and S.I. Awan, 2006. Genetic divergence, association and performance evaluation of different genotypes of mungbean (*Vigna radiata*). Int. J. Agric. and Biol., 8(6): 793-795.
30. Malik, M.F.A., A.S. Qureshi, M. Ashraf and A. Ghafoor, 2006. Genetic variability of the main yield related characters in soybean. Inter. J. Agri. and Biol., 8(6): 815-619.
31. Khan, I.A., 1988. Path coefficient analysis of yield attributes in mungbean (*Vigana radiata* L.). Legumes Res., 11: 41-43.
32. Amanullah and M. Hatam, 2000. Correlation between grain yield and agronomic parameters in mungbean (*Vigna radiate* L.). J. Biol. Sci., 3: 1242-1244.
33. Shamsuzzaman, K.M., M.R.H. Khan and M.A.Q. Saikh, 1983. Genetic variability and characters association in mung bean [*Vigna radiata* (L.) Wilczek]. Bangladesh Journal of Agricultural Res., 8: 1-5.
34. Poehlman, J.M., 1991. The Mungbeans. 1*st* Ed., Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.
35. Khan, A.M., M.A. Rahaman, M. Ahmed and A.F. Ahsan. 2010. Study on seed quality and performance of some mungbean varieties in Bangladesh. Int. J. Expt. Agric., 1(2): 10-15.
36. Karadavut, U., 2009. Path analysis for yield and yield components in Lentil (*Lens culinaris* Medik.). Turkish J. of Field Crops., 14: 97-104.
37. Lukman, H., 2008. Variability and correlation of agronomic characters of mungbean germplasm and their utilization for variety improvement program. Indonesian Journal of Agricultural Science, 9(1): 24-28.
38. Farrag, M.M., 1995. Yield of 23 mungbean accessions as affected by planting date under El –Minia condition. Assuit. J. Agric. Sci., 26(2): 49-62.
39. Kyei-Boahen S., C. Savala, D. Chikoye and R. Abaidoo, 2017. Growth and Yield Responses of Cowpea to Inoculation and Phosphorus Fertilization in Different Environments. Front Plant Sci., 8: 646.