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Research Article
Evaluation of Mungbean (*Vigna radiata* L. Wilczek) as Green Pod and Seed Crop under Different Cropping Systems in Egypt

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Abstract
Background and Objective: There is a shortage in the edible pulses in summer season in Egypt. In order to evaluate the potentiality of incorporating mungbean as a new crop in the crop structure in the Egyptian agriculture as vegetable or seed legume crop this study was conducted. **Material and Methods:** Four mungbean varieties from different origins were subjected to biological stress resulted when intercropped with maize at 2:2 intercropping pattern compared with solid planting. **Results:** The results showed significant gradual reduction in light energy flux density (Jm^{-2} sec^{-1}) at different heights for varieties, cropping systems and their interaction indicating the variability in the varietal tolerance to biological stress resulted from intercropping. There were insignificant differences among mungbean varieties in chl a, carotenoids, chl a+b/carotenoids. Significant differences ($p<0.05$) among mungbean varieties in macronutrients N, P, K and Mg concentration in leaves. There were significant differences among mungbean varieties in 4 key micronutrient (Fe, Mn, Zn and Cu) concentrations. The greatest N and Ca concentrations were found in NCM7 leaves while King and Kawmy-1 varieties contained the greatest concentrations of the micro nutrients Mn, Zn and Cu. There were significant interactions between variety and cropping pattern affected nutrient status for both macro and micro nutrient concentrations of mungbean leaves. **Conclusion:** It could be concluded from this study that mungbean could be employed and incorporated in the Egyptian structure as vegetable or field crop. Choosing the proper variety and cropping system could help in maximizing the productivity according to the purpose of utilization.

Key words: Intercropping, *Vigna radiata* L. Wilczek, carotenoids, micronutrients, light flux density

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) has been introduced to the Egyptian agriculture as a promising fieldcrop[1]. It is a short duration legume crop with low water requirements[2], with high nutritive value and known in both southern parts of Asia and Africa for human consumption[3]. Mungbean as a summer crop will compete with other summer dominant crops in Egypt. Another usage of mungbean it could be employed as vegetable crop for its green pods which could be cooked, however mungbean cultivation as a vegetable crop haven't a role in the Egyptian crop structure and untraditional practices like intercropping could be used for such purpose.

Intercropping of field crops is regarded as an essential practice when several economic field crops are competing for the same limited land area. Also, it is a common practice on small-scale farming system in the developing countries. Intercropping offers to farmers the opportunity to engage nature's principle of diversity at their farms. Spatial arrangements of plants, planting rates and maturity dates must be considered when planning intercrops. Dantata[4] in Nigeria, Eskandari[5] in Iran and Abd El-Lateef *et al.*[6,7] in Egypt, it have been emphasized that intercropping is the most effective tool which permits higher grain yields and greater land use efficiency per unit land area. Mungbean has a wide range of compatibility with other crop species in intercropping systems such as guar[8], maize[9], sesame[10], sunflower[11] and sweet corn[12].

When legume crops like mungbean grown as intercrop they suffer of biological stress due to shading form companion crop at different growth stages[13]. Nutrient status at grain filling stage, which appears to be very much sensitive to light conditions, needs special attention in dealing with the biological stress when intercropping is practiced, short mungbean plants suffered much more from competition than the tall crop plants in a mixture leading to the reduction of photosynthetically active radiation (PAS) and in turn reducing the biological efficiencies of legume nutritional status[14]. Unlu *et al.*[15] reported that cultivation of pea, either sole or between cauliflower or broccoli, did not cause any statistical effects over macro or micro element uptake at the fruits. The highest Ca (1.643%), Mg (0.693%) and Zn (47.030 ppm) were taken from cauliflower+pea intercropping and the highest P (0.837%), K (3.450%), Cu (7.666 ppm), Mn (16.950 ppm) and Fe (54.116 ppm) were obtained from broccoli+pea intercropping systems had an important effect on plant nutrient component in lettuce leaves for the amounts of N, P, Cu, Mn and Zn elements. However, at the sole cropping plots, intakes of P, Ca, Cu, Fe and Zn were less.

The objective of this study was to investigate the effect biological stress resulted from relay intercropping of maize on light energy flux density, photosynthetic pigments and macro and micro nutrient status of four mungbean varieties.

MATERIALS AND METHODS

Study area: Two field experiments were conducted in clay soil at private farm El Aiatt District , Giza Governorate, Egypt during 2017 and 2018 summer seasons to study the mineral status of macro and micronutrient status of leaves, growth and yield of mungbean biologically stressed by intercropping with maize grown at 2:2 intercropping pattern. The experimental design was split -plot with four replicates where the varieties occupied the main plots and the cropping patterns were allocated in the sub-plots. The area of each experimental plot was 21.6 m^2.

Four mungbean varieties were subjected to biological stress resulted from intercropping with maize at 2:2 patterns. The varieties were from different origins viz. Kawmy-1 (Egypt), VC1000 (AVRDEC), NCM-7 (Pakistan) and King (Australia) were used. Mungbean was planted in solid cultures at the densities of 447 and 700×10^3 plants ha^{-1} while maize was planted as solid cultures at 67.2 and 84×10^3 plants ha^{-1} for solid I (The recommended practice) and solid II (The planting density under intercropping pattern), respectively. The experimental soil was ploughed twice, ridged and divided to experimental plots. A boarder of 1 meter was left between each two experimental plots to avoid shading effects. Mungbean seeds were sown in hills 10 cm apart on ridges of 60 cm width (2 plants/hill) in intercropping and solid II cultures whereas, in solid I culture sowing was carried out at 15 cm hill space and 60 cm between ridges. Maize was also sown in hills at 25 cm space in solid I culture (1 plant/hill) while for solid II and intercropping patterns sowing was applied in hills 40 cm apart (2 plants/hill). Mungbean was sown in the assigned ridges in 12 and 15 May in 2017 and 2018 seasons, respectively. Two weeks later, before the first irrigation of mungbean. Maize was sown in the predetermined ridges. After the germination was completed, mungbean seedlings were thinned at 2 plants/hill to obtain the required density for each cropping pattern. Maize seedlings were thinned at 2 plants/hill for solid II and intercropping patterns while thinning was applied at 1 plant/hill for solid I culture. Mungbean seeds were inoculated with the specific Rhizobium strain. Phosphatic fertilization was applied in the form of calcium super phosphate 15.5% P_2O_5 at the rate of 260 kg ha^{-1} during seed-bed preparation. Nitrogen was added as a starter dose at 36 kg N ha^{-1} as ammonium nitrate 33.5% N while maize plants were fertilized with 252 kg N ha^{-1} in two doses 168 and 84 kg N before the first and second irrigations, respectively. Potassium fertilizer was applied as potassium sulphate 48% K_2O at 58 kg ha^{-1}.

The recommended agronomic practices for mungbean and maize were applied during the growing seasons. Mungbean plants flowered (50% flowering) at 39 and 43 days and matured after 87 and 93 days from sowing in 2017 and 2018 seasons, respectively. Maize tasseling occurred after 56 and 52 days, silking after 67 and 65 days from sowing and maturity after 120 and 117 days from sowing in 2017 and 2018 seasons, respectively. During the growing seasons, a vegetative sample were taken from mungbean leaves after 55 and 65 days from sowing to determine the photosynthetic pigments according to the method described by Lichtenthaler and Buschmann[16] and macro and micronutrient concentrations according to Cottenie *et al.*[17]. At complete green pod maturity each experimental unite one ridge was harvested to obtain green pods yield after 65 days and the other ridge was devoted to obtain seed yield at 80 and 100 days from sowing. Ten plants were taken randomly from each experimental unit, then green pod and dry pod number and weight, 100-seeds weight HI and seed yield per plant were determined. Two ridges of each crop were devoted to determine seed yield ha^{-1}, biological yield per hectare was determined from the above ground canopy (straw+pods). In this study mungbean data will only discussed while maize data will be discussed in another work.

Light interception measurements.

The light interception was measured for the solid and intercropping systems by using luxmeter in luxes[18], then the units were converted to energy flux density units in J m^{-2} sec^{-1} according to the relationship[19]:

- 1 w m^{-2} = 111.8 lux
- 1 w m^{-2} = 1 J m^{-2} sec^{-1}

Statistical analysis: The analysis of variance of split plot experiment was carried out using MSTAT-C[20] Computer Software 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 (LDS) 0.05 level.

RESULTS

Significant gradual reduction in light energy flux density (Jm^{-2} sec^{-1}) was reported at different heights for all varieties, cropping systems and their interaction (Fig. 1). Generally as expected, light intensity significantly decreased at mungbean different heights under intercropping systems compared with the solid planting SI and SII treatments.

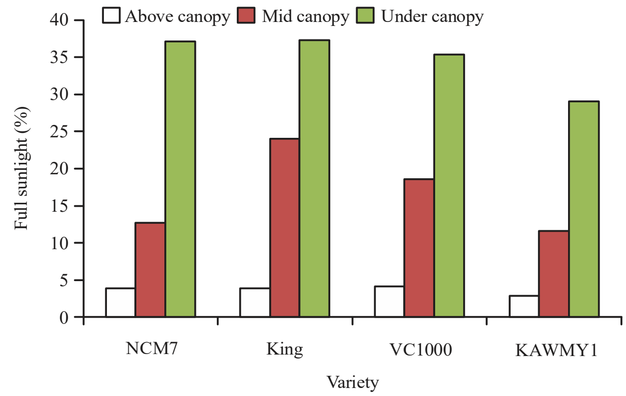

Fig. 1: Light intensity (%) of the full sun light at different mungbean highets

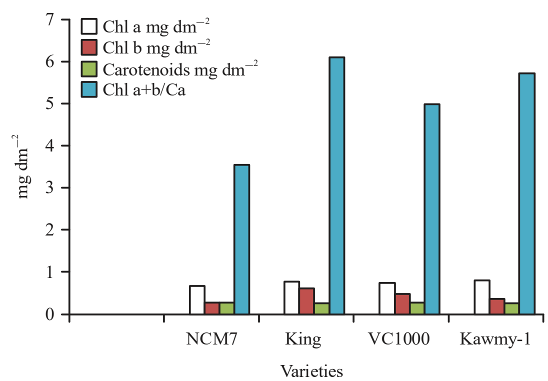

Fig. 2: Effect of mungbean varieties on photosynthetic pigments

The results of light intensity or pigmentation of varieties and cropping systems (Fig. 1, 2 and 3) indicate that there are varietal differences in light intensity percent under mungbean canopies. It reached (2.99%) for Kawmy-1recording the least percent reflecting the fact that the lower leaves are more parasitic for the assimilates formed than the other leaves at the same height in other varieties while the highest was VC1000 (4.15%). The results of the total Chl a+b/carotenoids reveal that King variety possessed the highest ratio (6.1 mg dm^{-2}) while the lowest was recorded by NCM-7 (3.54 mg dm^{-2}).

The data presented in (Fig. 2) clearly show that Kawmy-1 and King contained greater concentrations of chl a and chl a+b/carotenoids than that of NCM-7 and VC1000. Also, planting mungbean at solid II treatment (the higher density) and where the intercropping density is applied resulted in

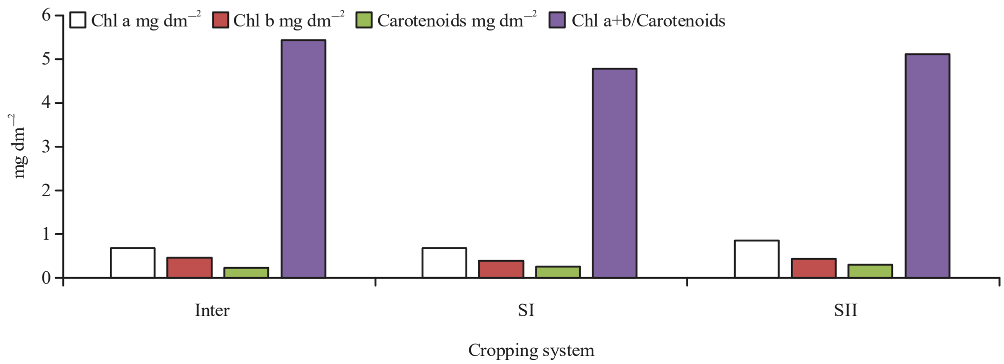

Fig. 3: Effect of cropping system on mungbean photosynthetic pigments
Inter: Intercropping system, SI: Solid I cropping system, SII: Solid II cropping system

Table 1: Effect of varietal differences and cropping system on macronutrient and micronutrient in mungbean leaves

	Macronutrients (%)					Micronutrients (mg kg^{-1})			
Treatments	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
Varieties									
NCM7	9.97	0.15	2.86	3.84	0.57	95.2	24.6	30.7	4.90
King	9.06	0.19	3.09	2.01	0.59	104.8	35.2	40.5	6.10
VC1000	7.73	0.17	3.51	1.87	0.57	128.5	25.6	32.5	6.00
Kawmy-1	7.09	0.17	3.41	2.43	0.66	112.2	33.1	34.7	6.00
LSD at 0.05	0.38	0.11	0.13	ns	0.02	5.77	2.25	3.08	0.25
Cropping system									
Inter 2:2	8.41	0.17	3.412	2.18	0.551	112.1	31.4	36.8	5.85
Solid I	8.51	0.17	3.025	2.89	0.643	108.0	27.8	32.4	5.66
Solid II	8.49	0.16	3.012	2.79	0.635	110.2	28.3	33.2	5.48
LSD at 0.05	ns	ns	0.093	ns	0.015	ns	1.59	2.1	ns

ns: Not significant

Table 2: Effect of the interaction (variety×cropping pattern) on macronutrient and micronutrient in mungbean leaves

		Macronutrients (%)					Micronutrients (mg kg^{-1})			
Varieties	Cropping system	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
NCM7	Inter 2:2	9.59	0.16	3.34	2.51	0.68	106.10	31.33	36.33	5.77
	Solid I	10.36	0.13	2.38	3.16	0.47	84.27	17.83	25.00	4.03
	Solid II	10.25	0.12	2.35	2.66	0.52	94.35	22.34	28.24	5.13
King	Inter 2:2	9.38	0.18	3.05	2.03	0.50	95.60	32.00	40.67	6.47
	Solid I	8.74	0.21	3.15	2.00	0.68	113.97	38.33	40.33	5.80
	Solid II	9.11	0.23	3.12	2.05	0.62	110.25	37.11	39.25	5.75
VC1000	Inter 2:2	7.27	0.17	3.61	1.68	0.37	129.33	25.33	38.67	5.60
	Solid I	8.19	0.17	3.41	2.05	0.77	127.67	25.83	26.33	6.40
	Solid II	7.82	0.18	3.52	1.89	0.56	115.65	24.88	32.14	5.83
Kawmy-1	Inter 2:2	7.40	0.18	3.68	2.52	0.66	117.50	37.00	31.33	5.57
	Solid I	6.77	0.16	3.16	2.35	0.65	106.80	29.17	38.00	6.43
	Solid II	7.11	0.17	3.35	2.44	0.55	111.19	33.45	36.78	6.54
LSD at 0.05		0.38	0.011	0.13	0.66	0.20	5.77	2.25	3.08	0.25

greater chl a, b and carotenoids compared with the solid recommended planting or the intercropping system (Fig. 3). The data of the interaction indicated that Kawmy-1 variety significantly contained the greatest chl a and chl a+b/carotenoids ratio under intercropping system. Moreover shading effects under intercropping reduced Chl a content (0.68 mg dm^{-2}) compared to solid II cropping system (0.8768 mg dm^{-2}).

Effect of variety and cropping system on nutrient concentration in mungbean leaves: The results in Table 1 and 2 showed significant differences ($p<0.05$) among mungbean varieties in macronutrients N, P, K and Mg. However, the differences in Ca concentration in mung bean leaves were insignificant. There were significant differences among mungbean varieties in the 4 key micronutrient (Fe, Mn, Zn and Cu) concentration. The greatest N and Ca

Table 3: Effect of variety and cropping pattern on mungbean green pods yield

Treatments	Number of green pods/plant	Green pods yield/plant (g)	Green pod yield ha^{-1} (kg)
Varieties			
NCM-7 (v1)	4.63	3.0	1408
King (v2)	9.00	12.5	4330
VC1000 (v3)	8.22	7.4	3234
Kawmy-1 (v4)	10.38	8.0	4578
LSD at 0.05	1.20	2.1	0.987
Cropping system			
2:2 (Inter)	7.05	2.2	2158
Solid I (SI)	9.15	3.7	3716
Solid II (SII)	7.65	3.1	3088
LSD at 0.05	1.40	1.1	ns
Variety×Cropping system			
NCM-7 (v1)			
2:2 (Inter)	2.43	2.6	1110
Solid I (SI)	6.32	6.0	1614
Solid II (SII)	5.14	3.4	1500
King (v2)			
2:2 (Inter)	5.50	10.1	3070
Solid I (SI)	12.90	15.0	6200
Solid II (SII)	8.60	12.2	4050
VC1000 (v3)			
2:2 (Inter)	6.60	4.3	2940
Solid I (SI)	10.00	9.4	5300
Solid II (SII)	8.06	8.50	4692
Kawmy-1 (v4)			
2:2 (Inter)	7.44	7.3	3200
Solid I (SI)	14.30	8.7	6300
Solid II (SII)	9.70	8.0	4234
LSD at 0.05	1.80	3.4	940

concentrations were found in NCM7 leaves King and Kawmy-1 varieties contained the greatest concentrations of the micronutrients Mn, Zn and Cu. Significant interactions affected nutrient status were evident for both macro and micronutrient conditions of mungbean leaves between variety and cropping pattern.

The results on macro and micronutrient concentration in mungbean leaves in Table 1 and 2 show that NCM-7 leaves contained the highest N % compared to the other varieties. King variety contained the highest values of Mn (35.2), Zn (40.5) and Cu (6.1) (mg kg^{-1}). VC1000 variety contained the greatest Fe values under any cropping system (115.65-129.33 mg kg^{-1}) compared to the other cropping systems and varieties. However, NCM7 contained the lowest micronutrient concentrations compared to the other varieties or under solid planting SI where the values were (Fe, Mn, Zn and Cu, 84.27, 17.83, 25.00 and 4.03 (mg kg^{-1}), respectively.

Effect of variety and cropping pattern on mungbean green pods yield: Data presented in Table 3 show significant differences among mungbean varieties in number of green pods/plant and green pods yield ha^{-1}. The greatest number of pods was formed by Kawmy-1followed by King and VC1000 without significant differences between them while the lowest was NCM-7. King variety possessed the highest green pod weight/plant followed by Kawmy-1 and the lowest was NCM-7. Green pods yield of Kawmy-1 and King (6300 and 6200 kg ha^{-1}, respectively) significantly surpassed the other two varieties and produced more than three folds of NCM-7 (1614 kg ha^{-1}) indicating that NCM-7 do not fit employing as green pods variety. It is also clear that the solid recommended practice treatment (solid I) significantly exceeded the intercropping treatments or the solid II treatment (where the intercropping density adopted) in number of green pods plant^{-1} and green pods yield ha^{-1}. Solid I and solid II treatments significantly exceeded the intercropped mungbean. Growing mungbean in number of green pods plant^{-1} and green pods yield ha^{-1} with the solid recommended density significantly surpassed solid II treatment. The data of the interaction (variety×cropping system) revealed significant differences in no. of green pods/plant and green pods yield ha^{-1}. Green pods yield was 1110, 3070, 2940 and 3200 kg ha^{-1} under intercropping system for the varieties NCM-7, King, VC1000 and Kawmy-1, respectively. Significant differences among green pods yield ha^{-1} were reported among mungbean varieties (Fig. 4).

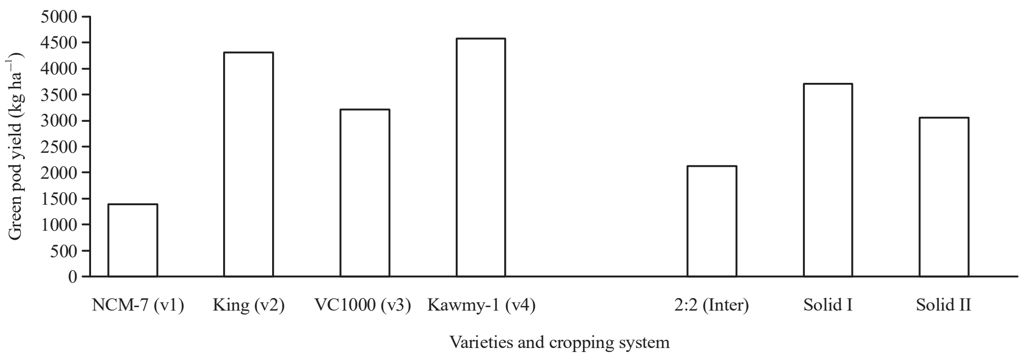

Fig. 4: Effect of variety and cropping pattern on mungbean green pods yield

Table 4: Effect of variety and cropping pattern on mungbean seed yield

Treatments	Number of pods/plant	Number of seeds/pod	Seed yield/ plant (g)	Seeds yield ha^{-1} (kg)	HI	Biological yield ha^{-1} (t)
Varieties						
NCM-7 (v1)	7.70	9.50	1.49	704	0.04	22.32
King (v2)	15.00	11.40	5.75	2165	0.29	10.31
VC1000 (v3)	13.70	10.60	3.71	1617	0.17	11.74
Kawmy-1 (v4)	17.30	11.60	4.02	2289	0.54	9.30
LSD at 0.05	1.20	0.99	0.90	478	ns	3.66
Cropping patterns						
2:2 (Inter)	11.75	10.60	2.22	1079	0.52	5.00
Solid I (SI)	15.25	11.00	4.66	1858	0.11	21.09
Solid II (SII)	12.75	10.70	4.35	1544	0.16	14.16
LSD at 0.05	1.40	ns	1.02	414	ns	3.17

ns: Not significant

Table 5: Effect of (variety×cropping pattern) on mungbean seed yield

Varieties	Cropping system	Number of pods/plant	Number of seeds/pod	Seed yield /plant(g)	Seed yield ha^{-1} (kg)	HI	Biological yield ha^{-1} (kg)
NCM-7 (v1)							
	2:2 (Inter)	6.1	8.5	1.37	648.2	0.075	9095
	Solid I (SI)	15.8	10.3	2.22	842.8	0.027	30852
	Solid II (SII)	12.9	9.8	0.87	620.2	0.023	27005
King (v2)							
	2:2 (Inter)	13.8	11.5	2.75	1232.0	0.475	2659
	Solid I (SI)	32.3	11.5	7.05	2679.6	0.202	14342
	Solid II (SII)	21.5	11.3	7.45	2583.0	0.191	13922
VC1000 (v3)							
	2:2 (Inter)	16.5	10.8	2.47	1089.2	0.240	4477
	Solid I (SI)	25.0	10.8	4.24	1897.0	0.100	20009
	Solid II (SII)	20.2	10.3	4.42	1863.4	0.172	10739
Kawmy-1 (v4)							
	2:2 (Inter)	18.6	11.8	2.30	1108.8	0.127	3778
	Solid I (SI)	35.8	11.5	5.12	3747.7	0.110	19169
	Solid II (SII)	24.3	11.5	4.64	2011.8	0.238	4967
LSD at 0.05		4.5	ns	1.10	413.3	ns	3166

HI: Harvest index ns: Not significant

Effect of variety and cropping pattern on mungbean seed yield: Data presented in (Table 4) show significant differences among mungbean varieties in number of pods/plant, number seeds/pod, Harvest index (HI), seed yield/plant and per hectare well as biological yield t ha^{-1}. NCM-7 recorded the lowest Number of pods, seeds per plant, HI, seed yield per plant and seed yield kg ha^{-1} as compared with the other mungbean varieties. However, NCM-7 significantly exceeded the other varieties in biological yield t ha^{-1}. King variety significantly surpassed the NCM-7 and VC1000 in number of pods/plant, number of seeds/pod and seed yield kg ha^{-1}. Meanwhile, insignificant differences were recorded among King, VC1000 and Kawmy-1 in HI and biological yield t ha^{-1}.

As expected, SI and SII treatments significantly exceeded the intercropping mungbean in all characters. Growing mungbean in the solid recommended density significantly surpassed solid II treatment in seed and biological yields ha^{-1}. The data of the interaction (variety$\times$cropping system) revealed significant differences in number of pods/plant, seed yield/plant and per hectare as well as biological yield characters (Table 5). The data clearly show that biological yield ha^{-1} Kawmy-1 proved to be the superior variety under intercropping system compared to the other varieties. However, NCM-7 performance shows that it is better to utilize it as forage crops under solid on intercropping systems. Seed yield ha^{-1} under solid recommended planting (SI) recorded the highest values 2679.6, 1897.0 and 3747.7 kg ha^{-1} for the varieties King, VC1000 and Kawmy -1, respectively.

DISCUSSION

The obtained results in relation to the effect of light intensity effects on intercropped mungbean clearly show that Kawmy-1 plants under intercropping patterns suffered from the severe reduction in light energy flux density at all measuring heights of the canopy than the other varieties. Under such circumstances of reduced light penetration, the lower plant leaves in the canopy become parasitic than the higher mungbean leaves. Moreover, such reduction in the biological stress may decrease the lower leaves of mungbean from being parasitic on the upper leaves[21]. In this respect, several investigators attributed the variability of legume tolerance to shading effects to the difference in the foliage architecture of the intercropped legumes[7,22-24].

Pigmentation data revealed that Kawmy-1 and King contained greater concentrations of chl a and chl a+b/ carotenoids. Such results reflect that Kawmy-1 is more tolerant to shading effects resulted from the competition of maize plants. Regarding the nutritional status of mungbean leaves it is worthy from these results that NCM7 variety was slower in translocation of the assimilates and the nutrient content formed in the leaves than the other varieties. Ghaffarzadeh[25] and Inal *et al.*[26] reported that Interspecific root interactions affect nutrient mobilization in the rhizosphere and contribute efficiently to nutrient acquisition by intercropping. Intercropping is also effective in improving mobilization and uptake of micronutrients other minerals in the rhizosphere, such as Ca and Mg. Similar results were obtained by Unlu *et al.*[15] they reported that according to macro and micro nutrient element analysis results carried out for leek leaves, with regard to sole cropping, intercropping did produce statistically significant effect on N and K uptake. Also, in the study the highest N (1.957%) and Fe (58.960 ppm) were obtained from sole leek application while highest P (0.597%), K (10.880%), Ca (3.440%), Mg (0.680%), Cu (4.840 ppm), Mn (29.660 ppm) and Zn (41.683 ppm) were obtained from broccoli. Some investigators reported that the mineral content was not significantly different in leaves of intercropped bean plants compared to those of the sole crop[27]. This can be explained by the efficient use of available resources/unit areas for different crops[28].

The differences in mungbean varieties in green pods no and yields could be attributed to the genetic characteristics and adaptability of such varieties under Egyptian climates. Moreover, the differences among these varieties in green pods yields could be attributed to their tolerance for biological stress resulted from intercropping[8,15].

The reduction in the intercropped legume growth and yield characters was reported by several investigators on legumes[13,28], also Khan *et al.*[8] showed a reduction percent in mungbean seed yield per plant by 44.6, 43.2 and 29.3% for the intercropping pattern 2:2, 2:3 and 2:4, respectively compared with the pure stand culture and for cowpea. Morgado and Willey[9] reported that intercropping significantly decreased bean biomass yield and harvest index at all bean populations as compared to sole cropping system. Also, Muoneke *et al.*[29] reported a reduction in the intercropped soybean seed yield per hectare by 42 and 46% in early and late seasons, respectively they attributed such reduction to the decrease in number of pods per plant. Also, Islam *et al.*[30] concluded that the reduction in photosynthetic active radiation caused significant reduction in pods per plant and thus there was a significant decrease in seed yield per plant. The relationship between growth characters and yield was reported by Mondal *et al.*[31], who observed that seed yield of mungbean had no positive relation with pod and seed size as well as harvest index. They added that genotypes, which had higher LA, TDM and CGR, also produced higher seed yield in mungbean. Meanwhile, Egli and Zhen-Wen[32] suggested that seeds per unit area were related to canopy photosynthesis during flowering and pod set and canopy photosynthesis rate was determined through LAI and CGR. Mondal *et al.*[33] mentioned that plant with optimum LAI and NAR may produce higher biological yield as well as seed yield. The dry matter accumulation may be the highest if LAI attains its maximum value within the shortest possible time. Furthermore, not only TDM production but also the capacity of efficient partitioning between the vegetative and reproductive parts may produce high economic yield[34].

CONCLUSION

It could be concluded from this study that mungbean could be employed and incorporated in the Egyptian structure as vegetable or field crop. Choosing the proper variety and cropping system could help in maximizing the productivity according to the purpose of utilization. Kawmy-1 seems to be more tolerant to shading effects under intercropping systems. However, NCM-7 performance shows that it is better to utilize it as forage crops under solid or intercropping systems.

SIGNIFICANCE STATEMENT

This study indicates that mungbean can be successfully grown and incorporated easily in the crop construction with different cropping systems either solid or intercropped. Therefore, it decreases the competition for the same land area of the vegetable or field crops grown under Egyptian conditions. Additional benefit of this study that it can add an edible pulse crop with high nutritive value since there is a shortage in the edible pulses in summer season in Egypt.

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