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Mungbean (*Vigna radiata* L. Wilczek) Varietal Tolerance to Biological Stress

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Abstract: Two field experiments were performed during the two successive summer seasons 2013 and 2014 in a private farm El- Gmalia district, Dakahlia Governorate, Egypt. The experiments aimed to study the effect of biological stress resulted from relay intercropping of maize of growth and yield on mungbean. Four mungbean varieties were subjected to biological stress resulted from intercropping with maize at 2:2 intercropping pattern. The results showed significant gradual reduction in light energy flux density (J m^{-2} s^{-1}) at different heights for varieties, cropping systems and their interaction. Kawmy-1 plants under intercropping pattern suffered from the severe reduction in light energy flux density at all measuring heights of the canopy than the other varieties. There were insignificant differences among mungbean varieties in photosynthetic pigments content. NCM-7 and King under intercropping pattern produced the greatest DM weight of stem, leaf and total DM/plant. Mungbean growing under intercropping system gave the highest growth attributes NAR, RGR and CGR at 55-65 days from sowing without significant differences compared with SI and SII cropping systems. NCM-7 recorded the lowest no. of pods, seeds per plant, HI, seed yield per plant and seed yield per hectare as compared with the other mungbean varieties. The data of biological yield / ha showed that Kawmy-1 proved to be the most superior variety under intercropping system compared to the other varieties although it suffers from illumination shortage but it seems that it has lower saturation point of light than the other varieties. It could be concluded from this study that Kawmy-1 possessed greater tolerance for biological stress than the other tested varieties. However, NCM-7 performance showed that it is better to utilize it as forage crops under solid on intercropping systems.

Introduction

In the last three decades, new crops have been incorporated successfully in the Egyptian agriculture to overcome the nutritional gap; i.e. soybean, sunflower, guar and millet .Recently, in the last decades, mungbean (*Vigna radiata* L. Wilczek) has been introduced to the Egyptian agriculture as a promising crop[1]. It is a short duration legume crop with low water requirements[2] and 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.

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. The early researches[4,5] and the recent works[6-8] in Egypt 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[9], maize[10] sesame[11], sunflower[12] and sweet corn[13].

Mungbean grown as intercrop suffers of shading stress form companion crop at different growth stages. Grain filling stage, which appears to be very much sensitive to light conditions, needs special attention to deal with, in order to maximize the benefit from intercropping systems[14]. When crop intensification through intercropping is practiced, short mungbean plants suffered much more from competition than the tall companion crop plants. Such phenomena may be due to the reduction in illumination intensity reaching the shorter canopy[15] leading to the reduction of photosynthetically active radiation (PAS)[16] and in turn reducing the biological efficiencies of legume[17].

It was reported that legume tolerance to intercropping varies according to the variety used. Sayed Galal and Metwally [18] evaluated 18 soybean varieties for intercropping with maize and found that the tolerance among different soybeans to intercropping expressed as yield reduction varied from 19 to 41 %.

Therefore, mungbean intercropping may be considered as one of the essential methods of incorporating such crop in the Egyptian agricultural structure. The objective of this study is to investigate the effect biological stress resulted from relay intercropping of maize on growth and yield of four mungbean varieties in order to fined the best compatible and tolerant to biological stress.

Materials and Methods

Two field experiments were conducted during the two successive summer seasons 2013 and 2014 in a private farm El-Gmalia district, Dakahlia Governorate, Egypt. The experiments aimed to study the growth and yield, of mungbean to relay intercropping with maize grown at 2:2 intercropping pattern. Four mungbean varieties from different origins viz. Kawmy-1 the only registered variety in Egypt, VC1000 (AVRDEC), NCM-7 (Pakistan) and King (Australia) were used. Mungbean was planted in solid cultures at the densities of 447 and 700 x 10^3 plants ha^{-1} while maize was planted as solid cultures at 67.2 and 84 x 10^3 plants ha^{-1} for solid I (The recommended practice) and solid II (The planting density under intercropping pattern), respectively. The planting densities of mungbean and maize were equal to 150 % of solid I treatment. Mungbean plants were intercropped with maize in 2:2 intercropping pattern by alternating 2 ridges of maize with 2 ridges of mungbean. The intercropping patterns provide 50 % of the cultivated area to maize and 50 % to mungbean. Thus the experiment included 12 treatments which were the combinations of four mungbean varieties and three cropping systems, intercropping, solid I and solid II. The treatments were arranged in factorial arrangement in four replicates.

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 cultures 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 2013 and 2014 seasons, respectively. Two weeks later, and before the first irrigation of mungbean. Maize was sown in the predetermined ridges.

After the germination was completed ،mungbean seedlings were thinned at two plants per hill to obtain the required density for each cropping pattern. Maize seedlings were thinned at two plants per hill for solid II and intercropping patterns while thinning was applied at one plant per hill for solid I culture. The theoretical numbers of maize, mungbean under the different cropping patterns are listed in Table -1.

Table 1. **The theoretical number of maize and mungbean plants under the different cropping patterns applied**.

Cropping pattern		Number of plants ha^{-1} x 10^3 plants	
Maize	**Mungbean**	**Maize**	**Mungbean**
2	2	42.000	350.000
Maize solid I (recommended)		67.200	…
Maize solid II (comparative)		84.000	…
Mungbean Solid I (recommended)		…	447.000
Mungbean Solid II (comparative)		…	700.000

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. 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 2013 and 2014 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 2013 and 2014 seasons, respectively. During the growing seasons, two vegetative samples were taken from mungbean after 55 and 65 days from sowing to determine the total dry weight per plant. Ten plants were taken at random for each plot to determine the following characters: plant height, number of leaves and branches/plant and dry weight of stem, leaves and total plant (g/plant). Growth attributes, i.e. net assimilation rate (NAR) in (g/cm^2/day), crop growth rate (CGR) in (g/cm^2/day) and relative growth rate (RGR) in (mg/g/day) were calculated at the growth stages. At maturity, ten plants were taken randomly from each experimental unit, then pod number and weight, 100-seeds weight and seed yield per plant were determined. Two ridges of each crop were devoted to determine seed yield per hectare. In this paper 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 according to[19] then the units were converted to energy flux density units in J m^{-2} s^{-1} according to the relationship described by [20].

1 w m-2 = 111.8 lux

1 w m^{-2} = 1 J m^{-2} s^{-1}

Statistical analysis.

The data were subjected to the proper statistical analysis using COHORT 6 package since the data in both seasons took similar trends، Bartlett's test was applied and the combined analysis of the data was done. For means comparison Least Significant Difference (LSD) at 5% level was applied.

Results and Discussion

Effect of intercropping systems on light interception photosynthetic pigments in mungbean.

Data presented in (Table 2) clearly indicate significant differences in light intensity at different measuring heights of mungbean plants under intercropping systems. Except for light intensity in the middle canopy, significant gradual reduction in light energy flux density (J m^{-2} s^{-1}) were reported at different heights for all varieties, cropping systems and their interaction (Table 2). Generally, as expected, light intensity significantly decreased at mungbean different heights under intercropping systems compared with the solid planting SI and SII treatments. From the same table, the data clearly show that Kawmy-1 plants under intercropping pattern suffered from the severe reduction in light energy flux density at all measuring heights of the canopy than the other varieties. The reduction in light penetration inside legume canopies was expected, but the data show that the biological stress resulted from the companion maize crop was minimized to reach similar values of light energy flux density under the same planting density in solid cultures of mungbean (SII) in mid and upper mungbean canopies. Such results indicate that the relay intercropping (cultivation a crop during a part of the life cycle of another crop) enabled mungbean seedlings to escape from the severe competition on light between maize and the legume crop since the later was grown two weeks earlier. Thus, the biological stress which resulted from the companion tall crop (maize) was relatively reduced especially at the lower heights of measuring in the intercropping although mungbean occupied the same proportion of land as maize. 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[22-24,7].

Table 2. Light energy flux density under, mid and above mungbean canopies under different cropping patterns. (Combined data over two seasons 2013 and 2014).

Treatment	Light Intensity J m^{-2} s^{-1}			Percentage*		
	under canopy	mid canopy	above canopy	under	Mid	upper
Varieties						
NCM-7 (v1)	105.1	341.7	999.8	3.89	12.66	37.03
King (v2)	101.6	648.8	1006.7	3.76	24.03	37.28
VC 1000 (v3)	112	501	953.6	4.15	18.56	35.32
Kawmy-1 (v4)	80.8	314	787.3	2.99	11.63	29.16
LSD 0.05	**ns**	**36.5**	**28.6**	**ns**	**1.35**	**1.06**
Cropping patterns						
2:2 (Inter)	78.8	436.4	962.8	2.92	16.16	35.66
Solid I (SI)	82.3	465.8	938.6	3.05	17.25	34.76
Solid II (SII)	138.5	452	909.1	5.13	16.74	33.67
LSD 0.05	**15.1**	**ns**	**21**	**0.56**	**ns**	**0.78**
Cropping patterns x Var.						
Inter x v1	83.1	436.4	900.5	3.08	16.16	33.35
Inter x v2	103.9	692.7	1059.8	3.85	25.65	39.25
Inter x v3	24.2	277.1	1045.9	0.90	10.26	38.74
Inter x v4	103.9	339.4	845.1	3.85	12.57	31.30
SI x v1	24.2	297.9	1059.8	0.90	11.03	39.25
SI x v2	103.9	637.3	976.7	3.85	23.60	36.17
SI x v3	131.6	630.3	928.2	4.87	23.35	34.38
SI x v4	69.3	297.9	789.6	2.57	11.03	29.25
SIl x v1	207.8	290.9	1039	7.70	10.77	38.48
SIl x v2	97	616.5	983.6	3.59	22.83	36.43
SIl x v3	180.1	595.7	886.6	6.67	22.06	32.84
SIl x v4	69.3	304.8	727.3	2.57	11.29	26.94
LSD 0.05	**29**	**36.5**	**28.6**	**1.07**	**1.35**	**1.06**

* % of the full sun light in the open air

Table 3. Effect of variety and cropping pattern on mungbean photosynthetic pigments in leaves. (Combined data over two seasons 2013 and 2014).

Treatment	Chl. a mg/dm^2	Chl. b mg/dm^2	Carotenoids mg/dm^2	Chl. (a+b) / Carotenoids
Varieties				
NCM-7 (v1)	0.67	0.27	0.28	3.54
King (v2)	0.78	0.60	0.26	6.10
VC 1000 (v3)	0.75	0.48	0.27	4.99
Kawmy-1 (v4)	0.81	0.36	0.26	5.72
LSD 0.05	**ns**	**0.11**	**ns**	**ns**
Cropping patterns				
2:2 (Inter)	0.68	0.44	0.24	5.42
Solid I (SI)	0.70	0.38	0.25	4.76
Solid II (SII)	0.87	0.46	0.31	5.09
LSD 0.05	**0.11**	**ns**	**ns**	**ns**
Cropping patterns x Var.				
Inter x v1	0.56	0.26	0.27	3.10
Inter x v2	0.65	0.42	0.26	4.14
Inter x v3	0.62	0.46	0.26	4.24
Inter x v4	0.91	0.61	0.18	10.21
SI x v1	0.69	0.33	0.23	4.55
SI x v2	0.55	0.53	0.17	6.98
SI x v3	0.84	0.32	0.34	3.44
SI x v4	0.73	0.34	0.27	4.05
SII x v1	0.74	0.22	0.33	2.95
SII x v2	1.14	0.85	0.35	7.18
SII x v3	0.79	0.66	0.22	7.30
SII x v4	0.79	0.13	0.34	2.91
LSD 0.05	**ns**	**0.11**	**ns**	**2.78**

The data presented in (Table 3) clearly show that there were insignificant differences among mungbean varieties in chl. a, carotenoids, (chl. a+b/carotenoids) whereas chl. b content in mungbean leaves was significant. The effect of cropping patterns was only significant on chl. a while the interaction (var. x cropping systems) significantly affected chl. b content. From the same table it seems 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 greater chl. a, b and carotenoids compared with the solid recommended planting or the intercropping system. 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. Such results reflect that Kawmy-1 is more tolerant to shading effects resulted from the competition of maize plants.

Plant height, No. of branches and Leaves.

Significant differences among mungbean varieties and cropping systems in plant height were reported (Table 4). However, the interaction (var. x cropping system) was insignificant. The data clearly show the effect of mungbean competition with maize. NCM-7 was the tallest mungbean varieties and significantly exceeded the other varieties. Similarly, mungbean plants under intercropping systems significantly exceeded the plants under solid plantings (SI and SII) in plant height. Such increase in plant height of NCM-7 match to the severe competition between NCM-7 and maize, which led the plants to etiolate to reach and capture light. Furthermore, the pigmentation criteria for NCM-7 confirm this assumption since NCM-7 leaves content the least chl. a, chl. b, under intercropping system. Also the interaction effect (var. x cropping systems) confirm this attitude.

Significant differences among mungbean varieties and cropping systems in number of branches and leaves per plant were reported. NCM-7 possessed the lowest no. of branches/plant and the greatest no. of leaves /plant indicating that it is specific character for such variety in distribution the leaves on the main stem. In addition, NCM-7 possessed the greatest no. of leaves under intercropping pattern compared to the solid planting confirming the main effect results.

Table 4. Effect of variety and cropping pattern on mungbean growth characters and dry matter accumulation. (Combined data over two seasons 2013 and 2014).

Treatment	Plant height (cm)	No. of branches/ plant	No. of leaves/ plant	Dry matter weight (g) (55 days)			Dry matter weight (g) (65 days)		
				Stems	Leaves	Total	Stems	Leaves	Total
Varieties									
NCM-7 (v1)	107.75	4.25	9.85	3.87	3.28	7.15	9.200	8.700	17.900
King (v2)	75.83	5.83	6.90	4.35	4.23	8.58	10.500	7.733	18.233
VC 1000 (v3)	82.00	5.75	6.07	4.23	3.83	8.07	6.217	5.650	11.867
Kawmy-1 (v4)	76.42	6.92	6.38	3.75	3.55	7.30	8.900	6.250	15.150
LSD 0.05	**6.07**	**0.84**	**1.04**	**ns**	**0.69**	**ns**	**2.217**	**1.380**	**2.655**
Cropping patterns									
2:2 (Inter)	96.06	6.00	7.81	4.10	3.66	7.76	9.263	8.300	17.563
Solid I (SI)	85.63	5.88	6.98	4.30	3.83	8.13	8.588	6.375	14.963
Solid II (SII)	74.81	5.19	7.11	3.75	3.69	7.44	8.263	6.575	14.838
LSD 0.05	**4.59**	**0.41**	**0.71**	**ns**	**ns**	**ns**	**ns**	**1.796**	**ns**
Cropping patterns x Var.									
Inter x v1	117.50	5.25	12.60	4.90	4.20	9.10	11.600	11.800	23.400
Inter x v2	87.50	6.25	7.45	4.05	4.00	8.05	13.450	9.100	22.550
Inter x v3	90.50	5.00	5.70	3.40	2.90	6.30	4.550	5.850	10.400
Inter x v4	88.75	7.50	5.50	4.05	3.55	7.60	7.450	6.450	13.900
SI x v1	105.00	4.25	6.90	4.05	3.10	7.15	6.650	5.900	12.550
SI x v2	77.00	6.25	8.65	4.90	5.15	10.05	11.300	7.900	19.200
SI x v3	83.75	6.50	6.05	4.95	4.45	9.40	8.100	5.800	13.900
SI x v4	76.75	6.50	6.30	3.30	2.60	5.90	8.300	5.900	14.200
SII x v1	100.75	3.25	10.05	2.65	2.55	5.20	9.350	8.400	17.750
SII x v2	63.00	5.00	4.60	4.10	3.55	7.65	6.750	6.200	12.950
SII x v3	71.75	5.75	6.45	4.35	4.15	8.50	6.000	5.300	11.300
SII x v4	63.75	6.75	7.35	3.90	4.50	8.40	10.950	6.400	17.350
LSD 0.05	**ns**	**ns**	**1.04**	**ns**	**0.69**	**1.41**	**2.217**	**1.380**	**2.655**

Dry matter of the different parts of mungbean varieties (stems, leaves and total) after 55 and 65 days from sowing are presented in (Table 4). Insignificant differences among mungbean plants in stem and total DM at 55 days from sowing were reported. Generally, mungbean varieties significantly differ in leaf DM. It is worthy to note that NCM-7 which was the tallest and possessed the greatest no. of leaves has the lowest DM weight of leaves reflecting that the superiority in plant height or no. of leaves could be attributed to the lower illumination which led to plant etiolating. From the same table, the data show that both King and VC1000 surpassed the other two varieties in total DM per plant at 55 days from sowing. The interaction (var. x cropping systems) was significant and the varieties King and NCM-7 gave the greatest DM/plant under intercropping while King produced the greatest DM in solid plantings (SI and SII). Significant differences in stem, leaf and total DM/plant were recorded among mungbean varieties as well as the interaction (var. x cropping systems) at 65 days from sowing. Meanwhile, only dry matter of leaves was significant due to cropping systems (Table 4). From the same table it is clear that NCM-7 and King varieties surpassed the other two varieties in stem, leaf and total DM at 65 days from sowing. Also, mungbean plants gave the greatest DM for stem, leaf and total DM under intercropping systems than the solid plants. In addition, NCM-7 and King under intercropping pattern produced the greatest DM weight for stem, leaf and total DM/plant whereas, King and NCM-7 surpassed the other varieties under Solid I planting and King and Kawmy-1 under solid II planting.

It is worthy to note that relay intercropping of mungbean with maize helped in minimizing the competition between legume crop and maize in the critical period of legume life cycle, especially at the early stage of growth, thus severe reductions in dry matter accumulation was not reported. The reduction in dry matter accumulation in the intercropped mungbean compared with the solid cultures could be attributed to the competition between legume plants on light as a result of the biological stress caused by the tall companion crop (maize) which decreased the photosynthesized metabolites and consequently the reduction in dry matter occurred. In this conceded the productivity of a crop depends on photosynthesis, partitioning, and transfer of assimilates to the economically important parts. The differences in canopy height of (mungbean and maize) the two species not only competed for nutrient and water but also for sunlight. The shading effect of tall intercropped maize may have adversely affected the biomass and photosynthesis of intercropped mungbean. Similar results were obtained by [25, 26, 6, 7]. Also Islam *et al*.[14] found that there was almost no difference between the control and 15 % shaded plants for all the parameters studied. Total dry weight was found to decrease with increase in shading intensity and this phenomenon continued till the maturity of the crop.

Growth attributes.

A) Leaf Area Index.

Significant differences among mungbean varieties were reported at 55 and 65 days from sowing (Table 5). The data clearly show that NCM-7 and King were the superior varieties in covering the unit of land area at 65 days from sowing. It seems that mungbean plants under intercropping systems succeeded in escaping from maize competition at the early growth stages which reflected in similar or greater LAI at 55 and 65 days from sowing. Such result may be due to the nature of relay intercropping system which permits mungbean plants to grow faster than maize by 15 days earlier. The data of the interaction (var. x cropping systems) confirm these results where LAI for NCM7 and King were greater under intercropping than that under solid plantings.

B) Leaf Area Ratio (LAR) and Leaf Weight Ratio (LWR).

The data of leaf area ratio did not reveal any significant differences due to varieties, cropping system and their interaction (Table 5). Concerning LWR criteria, it is clear from the data presented in Table 5 that insignificant effects due to varieties, cropping systems and their interaction were recorded at 55 and 65 days from sowing.

C) Net Assimilation Rate (NAR), Crop Growth Rate (CGR) and Relative Growth Rate (RGR).

Data in (Table 5) indicate that mungbean varieties differed in NAR at 55-65 days from sowing (the peak growth period). NCM-7 surpassed King and Kawmy-1 varieties in NAR without significant differences while VC1000 was the lowest mungbean variety in NAR. Similar results were reported for CGR and RGR at (55-65 days) growth period where NCM-7 significantly surpassed the other varieties in growth attributes. However, VC1000 possessed the lowest values of NAR, RGR and CGR at (55-65 days). From the same table it is obvious that growing mungbean under intercropping system gave the highest growth attributes NAR, RGR and CGR at 55-65 days from sowing without significant differences with SI and SII cropping systems. The interaction (var. x cropping system resulted in significant effects on RGR and CGR at 55-65 days from sowing. NCM-7 under intercropping system or the dense solid planting SII possessed the highest NAR at 55-65 days from sowing. However, the lowest variety in this criterion was VC1000. Islam *et al*.[14] reported than the crop growth rate, relative growth rate and net assimilation rate decreased due to shading resulting in lower specific leaf weight and plant height.

Table 5. Effect of variety and cropping pattern on mungbean growth attributes. (Combined data over two seasons 2013 and 2014).

Treatment	LAI 55 day	LAI 65 day	LWR 55 day	LWR 65 day	LAR 55 day	LAR 65 day	NAR ($mg/cm^2/day$) 55-65	CGR ($mg/cm^2/day$) 55-65	RGR (mg/g/day) 55-65
Varieties									
NCM-7 (v1)	4.925	6.525	2.093	2.188	2.093	2.188	0.486	0.019	1.075
King (v2)	6.350	5.800	2.239	1.951	2.239	1.951	0.434	0.016	0.965
VC 1000 (v3)	5.750	4.238	2.140	2.183	2.140	2.183	0.485	0.008	0.380
Kawmy-1 (v4)	5.325	4.688	2.192	1.887	2.192	1.887	0.419	0.017	0.785
LSD 0.05	**1.038**	**1.380**	**ns**	**ns**	**ns**	**ns**	**ns**	**0.005**	**0.280**
Cropping patterns									
2:2 (Inter)	5.494	6.225	2.129	2.183	2.129	2.183	0.485	0.016	0.980
Solid I (SI)	5.738	4.781	2.119	1.943	2.119	1.943	0.432	0.013	0.684
Solid II (SII)	5.531	4.931	2.250	2.031	2.250	2.031	0.451	0.015	0.740
LSD 0.05	**ns**	**0.796**	**ns**	**ns**	**ns**	**ns**	**0.049**	**ns**	**ns**
Cropping patterns x var.									
Inter x v1	6.300	8.850	2.047	2.318	2.047	2.318	0.515	0.020	1.430
Inter x v2	6.000	6.825	2.248	1.795	2.248	1.795	0.399	0.023	1.450
Inter x v3	4.350	4.388	2.076	2.536	2.076	2.536	0.564	0.009	0.410
Inter x v4	5.325	4.838	2.144	2.084	2.144	2.084	0.463	0.013	0.630
SI x v1	4.650	4.425	1.952	2.146	1.952	2.146	0.477	0.012	0.540
SI x v2	7.725	5.925	2.368	1.885	2.368	1.885	0.419	0.014	0.915
SI x v3	6.675	4.350	2.121	1.882	2.121	1.882	0.418	0.008	0.450
SI x v4	3.900	4.425	2.036	1.857	2.036	1.857	0.413	0.020	0.830
SII x v1	3.825	6.300	2.280	2.099	2.280	2.099	0.467	0.025	1.255
SII x v2	5.325	4.650	2.102	2.173	2.102	2.173	0.483	0.011	0.530
SII x v3	6.225	3.975	2.223	2.132	2.223	2.132	0.474	0.006	0.280
SII x v4	6.750	4.800	2.396	1.719	2.396	1.719	0.382	0.017	0.895
LSD 0.05	**1.038**	**1.380**	**ns**	**ns**	**ns**	**ns**	**ns**	**0.005**	**0.280**

It is well established that the relative growth rate (RGR) declined with age and the RGR was higher in high yielding genotypes than low yielding ones at early growth stages under solid cultures. However such tendency was opposite under biological stress conditions (intercropping). Koller *et al*.[27] observed a decrease in RGR as the season advanced. Moreover, Mondal *et al*.[28] indicated that the NAR declined at later growth stages (reproductive stage) which may be attributed to excessive mutual shading as the LA was maximum during this period and increased number of old leaves could have lowered the photosynthetic efficiency .Also, Pandey *et al*.[29] analyzed growth parameters of five varieties of black gram in order to study the physiological causes of yield differences and observed the differences in CGR, NAR, RGR, and LA among the varieties. They reported that in grain legume, the excess LA was reported to have lowered NAR drastically and resulted in a decreased dry matter accumulation, which probably resulted from excessive mutual shading. The relationship between growth attributes were explained by Mondal *et al.*[30] who obtained results revealed that a relatively smaller portion of TDM in mungbean was produced before flower initiation and the bulk of it after anthesis. The maximum CGR was observed during pod filling stage in all the varieties due to maximum leaf area (LA) development at this stage. They explained that the two plant characters LA and CGR contributed to the higher TDM production. Results indicated that high yielding mungbean varieties should possess larger LA, higher TDM production ability, superior CGR at all growth stages, and high relative growth rate and net assimilation rate at vegetative stage, which would result in superior yield components. Under the conditions of this experiment, the data of growth characters DM of stems, leaves and total DM and LAI clearly indicate that the inter-specific competition among mungbean varieties is greater than the intra-specific competition with the companion crop. Such effect may be due to the lesser competition between the different crop species than under the same crop.

Effect of mungbean varieties, cropping systems and their interaction on mungbean yield characters.

Data presented in (Table 6) show significant differences among mungbean varieties in no. of pods/plant, no. of seeds per pod, HI, seed yield per plant and per hectare well as biological yield t/ha. NCM-7 recorded the lowest no. of pods, seeds per plant, HI, seed yield per plant and seed yield kg/ha as compared with the other mungbean varieties. However, NCM-7 significantly exceeded the other varieties in biological yield t/ha. King variety significantly surpassed the NCM-7 and VC1000 in no. of pods/plant, no. of seeds/pod and seed yield kg/ha. Meanwhile, insignificant differences were recorded among King, VC1000 and Kawmy-1 in HI and biological yield t/ha.

Table 6. Effect of variety and cropping pattern on mungbean yield characters. (Combined data over two seasons 2013 and 2014).

Treatment	No. of pods/plant	No. of seeds/pod	Seed yield /plant	Seeds yield (kg/ha)	HI	biological yield (t/ha)
Varieties						
NCM-7 (v1)	7.7	9.5	1.49	704	0.042	22.32
King (v2)	15	11.4	5.75	2165	0.289	10.31
VC 1000 (v3)	13.7	10.6	3.71	1617	0.170	11.74
Kawmy-1 (v4)	17.3	11.6	4.02	2289	0.539	9.30
LSD 0.05	**1.2**	**0.987**	**0.90**	**478**	**ns**	**3.66**
Cropping patterns						
2:2 (Inter)	11.75	10.6	2.22	1079	0.515	5.00
Solid I (SI)	15.25	11.0	4.66	1858	0.110	21.09
Solid II (SII)	12.75	10.7	4.35	1544	0.156	14.16
LSD 0.05	**1.4**	**ns**	**1.02**	**414**	**ns**	**3.17**
Cropping patterns x var.						
Inter x v1	7	8.5	1.37	648	0.075	9.09
Inter x v2	13	11.5	2.75	1232	0.475	2.66
Inter x v3	12	10.8	2.47	1089	0.240	4.48
Inter x v4	15	11.8	2.30	1348	1.269	3.78
SI x v1	9	10.3	2.22	843	0.027	30.85
SI x v2	17	11.5	7.05	2679	0.202	14.34
SI x v3	16	10.8	4.24	1897	0.100	20.01
SI x v4	19	11.5	5.12	2012	0.110	19.17
SII x v1	7	9.8	0.87	620	0.023	27.00
SII x v2	15	11.3	7.45	2583	0.191	13.92
SII x v3	13	10.3	4.42	1863	0.172	10.74
SII x v4	18	11.5	4.64	1109	0.238	4.97
LSD 0.05	**1.9**	**ns**	**1.1**	**413**	**ns**	**3.17**

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 per hectare. The data of the interaction (var. x cropping system) revealed significant differences in no of pods/plant, seed yield/plant and per hectare as well as biological yield characters. The data clearly show that biological yield/ha Kawmy-1 proved to be the superior variety under intercropping system compared to the other varieties. However, NCM-7 performance show that it is better to utilize it as forage crops under solid on intercropping systems. The reduction in the intercropped legume growth and yield characters was reported by several investigators on legumes. Abd El–Lateef *et al.*[31,7] 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. Morgado *et al.*[10] 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.*[32] 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.*[14] 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 several investigators, Mondal *et al*.[33] 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[34] 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[35]. Furthermore, not only TDM production, but also the capacity of efficient partitioning between the vegetative and reproductive parts may produce high economic yield[36, 33].

Conclusion

It could be concluded from this study that Kawmy-1 due to the lower saturation point of light seems to be more tolerant to shading effects resulted from the competition of maize plants. However, NCM-7 performance show that it is better to utilize it as forage crops under solid or intercropping systems.

References

1. Ashour N.I., S. Abou Khadrah, H. Mosalem, M. E. Yakout, G. M. Zedan, M.E. Abd EL. Lateef E.M., Behairy T.G., Shaban Sh.A., Sharaan A.N., Selim M.M., Mahmoud S.A., Hassan M.W., Darwish G.G. and EL-Hifny M.Z. (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.
2. 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.
3. Lawn R. J. and Ahn C.S. (1985). Mungbean (*Vigna radiata* (L.) Wilczek / *Vigna mungo* (L.) Hepper), In " Grain Legume Crops (Eds: R. J. Summerfield and E.H Roberts) Collins, London 584-623.
4. Sayed Galal J.R., Hindi L., Ibrahim A.F. and EL-Hennawy H.H. (1974). Intercropping tolerance of soybean to different local corn stocks (*Zea mays* L.) Z Acker pflanzenbau 139 (2), 135-145
5. Sayed Galal, J.R., Hindi L., Abdalla M.F. and Metwally A.A. (1979). Soybean and corn under different intercropping patterns. World soybean Res. Conf, n- Raleigh, North Carolina, 69.
6. Abd El-Salam M.S. and El-Habbasha S.F. (2008). Evaluation of maize - mungbean intercropping system at different sowing dates for forage production. Egyptian J. of Agron., 30(2), 279-294.
7. Abd El–Lateef, E.M., M. Hozyn and Magda H. Mohamed (2010). Effect of maize –mungbean intercropping on light interception, yield and land use efficiency. Bull. NRC.,35, 2,169-184.
8. Abd El-Lateef E. M., M. S. Abd El-Salam, S.F. El-Habbasha and M. A. Ahmed (2015). Effect of maize - cowpea intercropping on light interception, yield and land use efficiency. Int. J. ChemTech Res., 8(6), 556-564.
9. Himayat U., Ayub K M., Qasim M., Subhan M. and Din R. (2001). Feasibility of intercropping Mungbean (*Vigna radiata*) in Guara (*Symposia psoraliodes*). J. Biol. Sci., 1(2), 65-66.
10. Morgado L.B. and Willey R.W. (2003). Effects of plant population and nitrogen fertilizer on yield and efficiency of maize-bean intercropping. Pesq. Agropec. Bras. Brasília, 38(11), 1257-1264.
11. Bhatti I., Ahmad H. R., Jabbar A., Nazir M.S. and Mahmood T. (2006). Competitive behavior of component crops in different Sesame-Legume intercropping systems. Inter. J. Agric. Biol., 8(2), 165-167.
12. Kandhro M. N., Tunio S. D., Memon H. R. and Ansari M. A. (2007). Growth and yield of sunflower under influence of mungbean intercropping. Pakistan Journal Engineering Veterinary Science, 23(1), 9-13.
13. Sarlak S., Aghaalikhani M. and Zand B. (2008). Effect of plant density and mixing ratio on crop yield in sweet corn/cowpea intercropping. Pakistan J. Biol. Sci., 11(17), 28-33.
14. Islam M.T., Kubota F., Mollah M.F.H., Agata W. (1993). Effect of shading on growth and yield of mungbean (*Vigna radiata* L. Wilczek). J. Agron. Crop Sci., 171, 274-278.

15. Behairy T. GH., N.I. Ashour, M.M. Selim and E.M. Abd EL-Lateef (1993). Effect of variety, cropping pattern and plant density on growth and yield of Sorghum-Soybean intercrops. 2. Soybean. Bull. NRC, Egypt, 18(4), 305-315.
16. Shen L. (1984). Yield responses of corn and soybean strip intercropping in different row directions. M. Sc. Thesis, Iowa state Univ., Ames. (Cited after Whingham, D. K. in world soybean Res. Conf., Procd, 1025-1031).
17. Ofori F. and Stern W.R. (1987). Cereal-Legume intercropping systems. Advances in Agron., 41: 41-90.
18. Sayed Galal J. R. and A. A. Metwally (1982). The variability in intercropping tolerance of 18 soybean varieties when grown with a newly developed maize stock. Res. Bull. Ain Shams Univ., Cairo, 2,1-15.
19. Pearce R.B., Brown R.H. and Blaser R.E. (1996). Relationship between leaf area index, light interception and net photosynthesis in orchard grass. Crop Sci., 5, 553-556.
20. Milthorpe F. L. and Moorby J. (1979). An Introduction to Crop Physiology. Cambridge International Student, Edition, 2*nd* Ed, London.
21. Ottman M. J. and Welch L. F. (1989). Planting patterns and radiation interception, plant nutrient concentration, and yield in corn. Agron. J., 81: 167-174.
22. Naveed A., Mirza M.H., Akhtar A. and Muhammad R. (2000). Intercropping maize with mungbean and cowpea under rained conditions. Pakistan J. Biol. Sci., 3(4), 647-648.
23. Tsub M. and Walker S. (2002). A model of radiation interception and use by maize –bean intercrop canopy. Agricultural and Forest Meteorology 3(110), 203-215.
24. Asmat U., Ashraf M.B., Gurmani Z. A. and Imran M. (2007). Studies on planting patterns of maize (*Zea mays* L.) facilitating legumes intercropping. J. Agric. Res., 45(2), 112-118.
25. Ghosh P.K. (2004). Growth, yield, competition and economics of groundnut/cereal fodder intercropping in the semi-arid tropics of India. Field Crops Res., 88, 227–237.
26. Ghosh P. K., Mannab M. C., Bandyopadhyayb K. K., Ajayb A. K., Tripathib R. H., Wanjarib K. M., Hatib A. K., Misrab C. L. and Subba R. A. **(**2006). Interspecific interaction and nutrient use in soybean/sorghum intercropping system. Agron. J., 98, 1097-1108.
27. Koller H.R., Nyquist W.E., Chorash I.S. (1970). Growth analysis of soybean community. Crop Sci., 10(4), 407- 412.
28. Mondal M. A., Hakim M. A., Juraimi A. S. and Azad M. A. (2011c). Contribution of morpho-physiological attributes in determining yield of mungbean. African Journal of Biotechnology, 10(60), 12897–12904.
29. Pandey R.K., Saxena M.C., and Singh V.B. (1978). Growth analysis of blackgram genotypes. Indian J. Agric. Sci., 48, 466–473.
30. Mondal M. A., Fakir M. S, Islam M. N. and Samad M. A. (2011a). Physiology of seed yield in mungbean: growth and dry matter production. Bangladesh J. of Botany, 40, 133-138.
31. Abd EL-Lateef E.M. (1993). Effect of mungbean (*Phaseolus aurus* Roxb) intercropping with maize (*Zea mays* L.) on productivity and land use efficiency. Egyptian J. Applied Sci., 8(5), 32-45.
32. Muoneke C. O., Ogwuche M. A. and Kalu B. A. (2007). Effect of maize planting density on the performance of maize/soybean intercropping system in a guinea savannah agro ecosystem. African J. Agric. Res., 2 (12), 667-677.
33. Mondal M. A., Fakir M. S., Juraimi A. S., Hakim M. A., Islam M. and Shamsoddoha A. T. (2011b). Effect of flowering behavior and pod maturity synchrony on yield of mungbean. Australian J. Crop Sci., 5, 945-953.
34. Egli D.B. and Zhen-wen Y. (1991). Crop growth rate and seeds per unit area in soybean. Crop Sci., 31(2), 439-442.
35. Sarwar G., Sadiq M.S., Saleem M. and Abbas G. (2004). Selection criteria in F3 and F4 population of mungbean. Pakistan J. Botany, 36(2), 297-310.
36. Hamid A., Agata W., Agata W., Maniruzzaman A.F. and Ahad A.M. (1989). Physiological aspects of yield improvement in mungbean. Proceedings of the 2*nd* National Workshop on Pulses; Gazipur, Bangladesh. BARI; pp. 95–102.

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