Vegetable Science (2019) 46 (1&2) : 60-65

Assessment of competitive indices in intercropping system of brinjal and palak

Sangeet Kumar*, SK Dhankhar, Vinod Kumar and Nidhi Sehgal

Received: March 2019 / Accepted: August 2019

Abstract

An assessment of the competitive indices in intercropping between brinjal and *palak* was carried out with the aim of increasing the productivity of these crops as well as to achieve the optimum utilization of all the available resources. For this purpose, an experiment consisting of 11 treatments with three replications in a Randomized Block Design (RBD) was conducted at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during autumn-winter season of 2016-17. Intercropping systems were assessed by land equivalent ratio (LER), area-time equivalent ratio (ATER), relative crowding coefficient (K), aggressivity (A), competition ratio (CR), actual yield loss (AYL) and intercropping advantage (IA). Competition indices like CEY, LER, ATER and K were found to be superior for the paired row brinjal + *palak* (two rows). Although, the treatment brinjal + *palak* (three rows) was found better in terms of indices like A, CR, AYL and IA. This might be due to the interspecific and intraspecific competition between brinjal and *palak* for space, nutrients, light and available resources. LER, ATER and K values were greater than 1 for all the intercropping treatments. These findings showed an advantage of intercropping for exploiting the resources of the environment optimally.

Keywords: Brinjal, *palak*, intercropping, competitive indices

Introduction

To combat climate change as well as to meet the nutritional and economic requirements of the ever-increasing population, which is now becomes the major challenge for the scientific community and political decision-makers, where the choice of an ideal cropping system has become need of the hour. Sustainable agriculture is a type of agriculture that is more efficient in use of resources, for the benefit of humanity, and is in balance with the environment. Intercropping as a tool for sustainable subtropical agriculture must be involved in such systems, which is expected to withstand a wide range of ecological and climatic factors. As the cultivable land is decreasing day-by-day, it is indispensable to realize sustainable intercropping systems, so that available growth resources could be utilized optimally. The success of such investigations is strongly linked to several factors, among which crop husbandry and varieties, or cultivars are the prerequisites. Brinjal (*Solanum melongena* L.) and *palak* (*Beta vulgaris* var. *orientalis* L.) are excellent plant models for intercropping in the subtropical regions. Brinjal, a tropical perennial but often cultivated as an annual herbaceous plant with semi-erect or semi-spreading growth habit, cultivated worldwide for its fleshy berries. India ranks second after China for area and production of brinjal in the world, accounting 730 thousand hectares with an annual production of 128 lakh tonnes and productivity of 17.53 tonnes per hectare (Anonymous 2018). Owing to its high production rate, it is a good source of income to small as well as marginal farmers in developing countries. The initial growth of its plants is quite slow despite having sufficient space between and within the rows, which can be utilized to raise fast growing short duration crops such as intercrop for generating supplementary income from same space. The practice of intercropping in different vegetables have already been studied and concluded that *palak* had better companion effect on the yield of brinjal as compared to radish and coriander if taken as intercrop (Rodge and Yadlod 2009).

Palak or beet leaf (*Beta vulgaris* var. *orientalis* L.), a short duration leafy vegetable, can be grown in tropical and subtropical regions throughout the year at a spacing of 20x5 cm. The *palak* crop becomes ready for its first cutting in about 35 days after sowing and subsequent cuttings can be done around 15 days interval. Several factors can affect the growth and yield of the species in mixture, particularly planting ratio, spatial arrangement,

Department of Vegetable Science, CCS Haryana Agricultural University, Hisar-125004, Haryana
*Corresponding author, Email: ssagwal503@gmail.com

plant density, cultivar and competition between mixture components (Rezaei-Chianeh et al. 2011). High yields are achieved with intercropping when interspecific competition is lower than intraspecific (Zhang et al. 2011). There is a great possibility to cultivate minimum canopy spread herbaceous plants like *palak* in the inter row space of brinjal as they belong to different growth habits and duration. The assessment of competition and agronomic advantages of intercropping can be conducted using indices such as land equivalent ratio, relative crowding coefficient, competitive ratio, aggressivity and actual yield loss (Connolly et al. 2001, Weigelt and Jolliffe 2003). Recent reports envisage that such investigation has need to be carried out in brinjal and *palak* for intercropping systems in India and no recommendation on this aspect exists for Haryana region. Keeping in view the above issue, research is formulated based on several competition indices, to find out the best combination and efficiency of *palak* productivity for intercropping at different planting densities with brinjal in terms of agronomic advantages.

Materials and Methods

The research was carried out at the experimental farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, with semi-arid subtropical climate during *kharif* season, 2016-17. The soil type was a well-drained sandy loam with pH and electric conductivity (EC) values are 8.13 and 0.26 dS/m respectively. Five-week-old seedlings of brinjal cv. HLB 12, tolerant to shoot and fruit borer, were transplanted at spacing of 60×60 cm for single row and 30/60x60 cm for paired row in plots of 3.6 x 4.2 m on 25th July. Seeds of *palak* cv. HS 23 were sown at 20x5 cm spacing in between brinjal rows as intercrop. The experimental design used was Randomized Block Design (RBD) in triplicate of 11 intercropping treatments like T_1- brinjal sole crop, T_2- *palak* (sole), T_3-paired row brinjal sole crop, T_4- brinjal + *palak* (broadcasting), T_5- brinjal + *palak* single row, T_6- brinjal + *palak* two rows, T_7- brinjal + *palak* three rows, T_8- paired row brinjal + *palak* single row, T_9- paired row brinjal + *palak* two rows, T_{10}- paired row brinjal + *palak* three rows and T_{11}- paired row brinjal + *palak* four rows. To record the fruit yield and green leaf data, the first picking of brinjal fruits was done at 60 days after transplanting and the subsequent pickings were taken at 10 days regular interval. In case of *palak*, only three leaf cuttings were taken. The first one was done at 35 days after sowing and subsequent two cuttings were taken at 50 and 65 days after sowing., Different indices like crop equivalent yield, Land equivalent ratio, Area time equivalent ratio, Land equivalent coefficient, Relative crowding coefficient, Aggressivity, Competition ratio, Actual yield loss and Intercropping advantage were calculated as suggested by Connolly et al. (2001) and Weigelt and Jolliffe (2003) to determine to what extent these different intercropped species compete against each other.

Crop Equivalent Yield (CEY): The brinjal and *palak* equivalent yield were calculated by converting the yield of *palak* and brinjal based on market price of individual crop by the following formula:

$$CEY= Y_m + Y_i \times P_i / P_m$$

Where,

Y_m = Yield of main crop in intercropping system (q/ha)

Y_i = Yield of intercrop in intercropping system (q/ha)

P_m = Price of main crop (Rs.)

P_i = Price of intercrop (Rs.)

Land Equivalent Ratio (LER): The advantages of *palak* and brinjal intercropping were evaluated using the LER (Willey and Osiru 1972). If LER>1, it indicates that intercropping favours the growth as well as the yield of the species. In contrast when LER<1, there is no intercropping advantage and the inter-specific competition is stronger than the inter-specific interaction within intercropping system (Zhang et al. 2011). LER was calculated as given below:

$$LER = (LER_{brinjal} + LER_{palak})$$

$$LER_{brinjal} = Y_{bi}/Y_b$$

$$LER_{palak} = Y_{pi}/Y_p$$

Where, Y_b is the yield of brinjal as sole crop

Y_p is the yield of *palak* as sole crop

Y_{bi} is the yield of brinjal as intercrop

Y_{pi} is the yield of *palak* as intercrop

Area Time Equivalent Ratio (ATER): More realistic comparison of the yield advantage of intercropping over monocropping in terms of time taken by component crops is mainly provided by ATER (Yahuza 2011). ATER was calculated using the following formula:

$$ATER = (ATER_{brinjal} + ATER_{palak}) = LER \times Dc/Dt$$ (Heibsch 1980)

Where,

LER: land equivalent ratio of crop

Dc: time taken by crop

Dt: time taken by whole system

Land Equivalent Coefficient (LEC): It is a measure of interaction concerned with the strength of relationship and therefore calculated as:

$LEC = LER_{brinjal} \times LER_{palak}$

For a two-crop mixture, the minimum expected productivity coefficient is 25% i.e. a yield advantage is obtained if LEC value exceeds 0.25.

Relative Crowding Coefficient (K): It measures the dominance of one species over the other in a mixture.

$K = K_{brinjal} \text{ x } K_{palak}$

Where,

$K_b = Y_{bi} \text{ x } Z_{pi} /(Y_b\text{-}Y_{bi}) \text{ x } Z_{bi}$

$K_p = Y_{pi} \text{ x } Z_{bi} /(Y_p\text{-}Y_{pi}) \text{ x } Z_{pi}$

Z_{bi} and Z_{pi} were proportions of brinjal and *palak* in the intercrops, respectively. When the value of RCC is greater than 1, there is a yield advantage. But when it is equal to 1, there is no yield advantage.

Aggressivity (A): It is a competitive index, which is a measure of how much the relative yield of one crop component is greater than that of another (Mc Gilchrist 1965). Aggressivity is expressed as

$A_{brinjal} = (Y_{bi}/Y_b \times Z_{bi}) – (Y_{pi}/Y_p \times Z_{pi})$

$A_{palak} = (Y_{pi}/Y_p \times Z_{pi}) – (Y_{bi}/Y_b \times Zb_i)$

If $A_{brinjal}$ or $A_{palak} = 0$, then both crops are equally competitive. When $A_{brinjal}$ is positive, it indicates that the brinjal species is dominant over *palak* and when it is negative then *palak* is the dominating one.

Competitive Ratio (CR): It simply denotes the ratio of individual LERs of the component crops and takes into account the proportion of the crops in which

$CR_{brinjal} = (LER_b /LER_p) \text{ x } (Z_{pi}/Z_{bi})$

$CR_{palak} = (LER_p /LER_b) \text{ x } (Z_{bi}/Z_{pi})$

If $CR_{brinjal}>1$, brinjal will be more competitive than *palak*, and if $CR_{brinjal}<1$, then brinjal will be less competitive than *palak* (Zhang et al. 2011).

Actual Yield Loss (AYL): It defines the proportionate yield loss or gain of intercrops compared to sole crop based on yield per plant (Banik et al. 2000). The positive or negative values of AYL indicate the advantage or disadvantage of the intercropping, respectively.

$\text{Actual Yield Loss} = AYL_{brinjal} + AYL_{palak}$

$AYL_{brinjal} = \{ [(Y_{bi}/Z_{bi}) /(Y_b /Z_b)] – 1\}$

$AYL_{palak} = \{ [(Y_{pi} /Z_{pi}) / (Y_p /Z_p)] – 1\}$

Intercropping Advantage (IA)

$IA = [(P_b/P_b+P_p) \text{ x } AYL_p] + [(P_p/P_p+P_b) \text{ x } AYL_b]$

In this equation, P_b is the price of brinjal, P_p is the price of *palak*, AYL_b is the partial actual yield loss or gain of brinjal and AYL_p is the partial actual yield loss or gain of *palak*.

Results and Discussion

Brinjal equivalent yield (BEY) and *Palak* equivalent yield (PEY): Results obtained revealed that all the intercropping treatments showed higher value for these yield attributes over the sole cropping (Table 1). The maximum value for BEY and PEY was recorded for the treatment paired row brinjal + *palak* two rows followed by brinjal + *palak* single row. The increase in yield of brinjal might be attributed to the increase in growth attributes, number of fruits per plant and fruit weight, as the main crop brinjal was slow growing and *palak* as intercrop was fast growing with higher price received in the market to give substantial yield advantage. Similar findings were reported by Singh et al. (2016) in potato-based intercropping and Islam et al. (2014) in brinjal-coriander intercropping system.

Table 1. Total fruit yield of brinjal, total leaf yield of *palak*, brinjal equivalent yield and *palak* equivalent yield of brinjal + *palak* intercropping system

Treatments	Total fruit yield (q/ha)	Total leaf yield	Brinjal equivalent yield (q/ha)	*Palak* equivalent yield (q/ha)
Brinjal sole (60 X 60 cm)	335.3	-	335.3	143.7
Palak sole (20 X 5 cm)	-	98.8	230.5	98.8
Paired row brinjal sole (30/60 X 60 cm)	318.3	-	318.3	136.4
Brinjal + *palak* (broadcasting)	260.3	73.9	432.6	185.4
Brinjal + *palak* (single row)	319.7	79.7	505.7	216.7
Brinjal + *palak* (two rows)	287.8	82.8	481.1	206.1
Brinjal + *palak* (three rows)	266.5	95.8	489.9	209.9
Paired row brinjal + *palak* (single row)	299.7	79.2	484.5	207.6
Paired row brinjal + *palak* (two rows)	293.3	91.9	507.6	217.6
Paired row brinjal + *palak* (three rows)	257.3	90.4	468.1	200.6
Paired row brinjal + *palak* (four rows)	250.3	86.9	453.1	194.2
SEm±	7.0	1.1	-	-
CD at (p= 0.05)	21.0	3.3	-	-

Land equivalent ratio (LER), land equivalent coefficient (LEC) and area-time equivalent ratio (ATER): Data presented in Table 2 exhibited variations in land equivalent ratio (LER), land equivalent coefficient (LEC) and area-time equivalent ratio (ATER) due to intercropping of *palak* with brinjal in different treatments. LER and ATER in all the intercropping treatments were higher than unity. Similarly, land equivalent coefficient values recorded were greater than 0.25 which indicates yield advantage. LER, LEC and ATER recorded the highest for treatment paired row brinjal + *palak* two rows (1.84, 0.85 and 1.46 respectively), followed by brinjal + *palak* single row (1.76, 0.77 and 1.43 respectively) and the lowest for brinjal + *palak* (broadcasting), i.e., 1.51, 0.57 and 1.91, respectively, among various intercropping combinations. The treatments having higher value of LER, LEC and ATER indicated that these intercropping systems utilized the available land and space properly with respect to time. Higher LER and ATER values in intercropping system in comparison to sole cropping were also reported by Kumar et al. (2014) and Singh et al. (2016). Kheroar and Patra (2014) also reported LEC value greater than 0.25 while working on paired row maize-legume intercropping system.

Relative crowding coefficient (RCC), Aggressivity and Competition ratio: Total K values for all intercropping treatments were more than one, designating the definite yield advantage due to intercropping. Total K value ranges from 132.3-9.54 (Table 3), with maximum for paired row brinjal + *palak* (two row) and minimum for brinjal + *palak* (broadcasting). Partial K values of brinjal was more than of *palak*, indicating that brinjal is more competitive than its associated crop, except the combinations where three or more rows of *palak* intercropped with either normal or paired row brinjal. The aggressivity values indicated that brinjal dominated the *palak* in most of the cropping systems tested (Table 3). This dominance was more pronounced in the combination brinjal + *palak* (two row & three row). On the contrary, *palak* was more aggressive in the association of paired row brinjal + *palak* (one & two row). In all treatments, the CR of brinjal was greater than unity except paired row brinjal + *palak* (one & two row) (Table 3). This highest value of CR was observed from brinjal + *palak* (three row) followed by brinjal + *palak* (two row), indicating brinjal superior ability of competition than that of *palak*. However, the CR of *palak* was greater than unity when its single row intercropped with paired row brinjal. Lower differences in CR values revealed the better utilization of growth resources.

Competitive abilities of component crops in intercropping can be evaluated by A, K and CR (Weigelt and Jolliffe 2003). Li et al. (2001) reported that the yield of an intercropping system is positively associated with the interspecific competition of the component crops. According to values obtained for A, K and CR, the

Table 2. Land equivalent ratio (LER), land equivalent coefficient (LEC) and area time equivalent ratio (ATER) of brinjal + *palak* intercropping system

Treatment	Land equivalent ratio			Land equivalent coefficient	Area time equivalent ratio
	Brinjal	*Palak*	Total		
Brinjal sole (60 X 60 cm)	1	-	1.00	-	1.00
Palak sole (20 X 5 cm)	-	1	1.00	-	1.00
Paired row brinjal sole (30/60 X 60 cm)	1	-	1.00	-	1.00
Brinjal + *palak* (broadcasting)	0.77	0.74	1.51	0.57	1.19
Brinjal + *palak* (single row)	0.95	0.81	1.76	0.77	1.43
Brinjal + *palak* (two rows)	0.85	0.83	1.68	0.71	1.34
Brinjal + *palak* (three rows)	0.79	0.96	1.75	0.76	1.34
Paired row brinjal + *palak* (single row)	0.94	0.8	1.74	0.75	1.40
Paired row brinjal + *palak* (two rows)	0.92	0.92	1.84	0.85	1.46
Paired row brinjal + *palak* (three rows)	0.81	0.91	1.72	0.74	1.33
Paired row brinjal + *palak* (four rows)	0.79	0.87	1.66	0.69	1.28

Table 3. Relative crowding coefficient (RCC), Aggressivity and Competition ratio of brinjal + *palak* intercropping system

Treatment	Relative crowding coefficient			Aggressivity		Competition ratio		
	Brinjal	*Palak*	Total	Brinjal	*Palak*	Brinjal	*Palak*	Difference
Brinjal + *palak* (broadcasting)	3.35	2.85	9.55	0.03	-0.03	1.04	0.96	0.08
Brinjal + *palak* (one row)	19.00	4.26	80.94	0.15	-0.15	1.17	0.85	0.32
Brinjal + *palak* (two row)	5.67	4.88	27.67	0.44	-0.44	2.04	0.49	1.55
Brinjal + *palak* (three row)	3.77	24.00	90.48	0.47	-0.47	2.46	0.41	2.05
Paired row brinjal + *palak* (one row)	15.67	4.00	62.68	-0.35	0.35	0.59	1.70	-1.11
Paired row brinjal + *palak* (two row)	11.50	11.50	132.25	-0.02	0.02	1.00	1.00	0.00
Paired row brinjal + *palak* (three row)	4.26	10.11	43.07	0.08	-0.08	1.33	0.75	0.58
Paired row brinjal + *palak* (four row)	3.77	6.69	25.22	0.16	-0.16	1.82	0.55	1.27

Table 4. Actual yield loss (AYL), and Intercropping advantage (IA) of brinjal + *palak* intercropping system

Treatment	Actual yield loss			Intercropping advantage		
	Brinjal	*Palak*	Total	Brinjal	*Palak*	Total
Brinjal + *palak* (broadcasting)	0.55	0.50	1.05	0.39	0.15	0.54
Brinjal + *palak* (one row)	0.91	0.61	1.52	0.64	0.18	0.82
Brinjal + *palak* (two row)	1.57	0.26	1.83	1.10	0.08	1.18
Brinjal + *palak* (three row)	2.18	0.30	2.48	1.53	0.09	1.62
Paired row brinjal + *palak* (one row)	0.34	1.40	1.74	0.24	0.42	0.66
Paired row brinjal + *palak* (two row)	0.75	0.85	1.60	0.53	0.26	0.78
Paired row brinjal + *palak* (three row)	0.92	0.52	1.44	0.64	0.16	0.80
Paired row brinjal + *palak* (four row)	1.24	0.32	1.56	0.87	0.10	0.96

component crop did not exhibit equal competitive intensity except treatments, paired row brinjal + *palak* (one & two row), which might be due to higher intraspecific competition between paired row brinjal. And greater competitiveness of brinjal in the rest of intercropping system with *palak* might be attributed to shading, space occupied by the brinjal crop and intraspecific competition within *palak* crop. Indeed, spreading type growth of brinjal and high brinjal proportion in the mixtures could affect nutrient availability and light interception by *palak*. Islam et al. (2016) found that brinjal was the dominant species in brinjal-garlic intercropping system. In terms of the advantage of intercropping systems, K indicated nearly similar trends with LER.

Actual yield loss (AYL) and Intercropping advantage (IA): In all the treatments, the AYL of the *palak* had positive values in the association of both normal and paired row brinjal. This result indicated the yield advantage for *palak* (Table 4). Brinjal was dominant because the partial AYL of brinjal was greater than that of *palak*, besides paired row brinjal + *palak* (one & two row). The best value of AYL_{palak} was found in its association with paired row brinjal + *palak* (one row), indicating the best combination and planting configuration for this crop. This result suggested an advantage of intercropping system compared to pure culture. In these cases, there was an increase in yield of intercropping system that ranged from 105% to 248% (AYL = +1.05 to +2.48) as compared to sole crop yield. The highest values (2.48 and 1.83) of AYL were found in the association brinjal + *palak* (two & three row). These advantages could be attributed to the better utilization of growth resources and to the low competition between *palak* and brinjal maintained by optimum proportion of both component crops (Nassab et al. 2011, Zhang et al. 2011).

According to Banik et al. (2000), IA, can be an indicator of the economic feasibility of intercropping systems. As measured by IA, the most advantageous mixture was brinjal + *palak* (two & three row) (Table 4). The fact that IA values (0.54-1.62) were positive, indicates that these intercropping systems had the economic advantage. Result was probably be attributed to better use of resources such as light, water and nutrients due to optimum proportion and space maintained in this treatment. Similar findings were collaborated by Koohi and Nasrollahzadeh (2014) in sorghum-moongbean intercropping system.

Conclusion

Results obtained from competition indices showed a significant advantage from intercropping for exploiting the available resources of the environment at its optimum compared to sole cropping which might be the result of better economics and land use efficiency. Competition indices like CEY (507.6 q/ha), LER (1.84), ATER (1.46) and K (132.25) were superior for the paired row brinjal + *palak* (two rows). Although, the treatment brinjal +*palak* (three rows) was found superior in terms of indices like A (0.47), CR (2.05), AYL (2.48) and IA (1.62). This might be due to the interspecific and intraspecific competition between brinjal and *palak* for space, nutrients, light and available resources. However, from farmer's point of view, the treatment paired row brinjal + *palak* (two rows) was the most remunerative with B:C (3.52) among all the respective treatments due to its higher CEY (507.6 q/ha) and LER (1.84).

lkjka'k

बैंगन एवं पालक के बीच परस्पर क्रिया में प्रतिस्पर्धी सूचकांकों का मूल्यांकन उत्पादकता बढ़ाने के साथ–साथ सभी उपलब्ध संसाधनों के इष्टतम उपयोग को प्राप्त करने के उद्देश्य से परीक्षण किया गया। इस उद्देश्य के लिए 2016–17 के शरद ऋतु–सर्दियों के मौसम के दौरान प्राप्त करने के वनस्पति विज्ञान विभाग, चौधरी चरण सिंह हरियाणा कृषि विश्वविद्यालय, हिसार (हरियाणा) के प्रक्षेत्र पर तीन बार प्रतिकृति कर रैण्डमाइज्ड ब्लॉक डिजाइन में 11 उपचारों को समाहित कर किया गया। अन्तःफसल का मूल्यांकन भूमि समतुल्य अनुपात (एलइआर), क्षेत्र–समय समतुल्य अनुपात (एटीइआर) सापेक्ष समूह गुणांक (के), आक्रामकता (ए), प्रतियोगी अनुपात (सीआर), वास्तविक उपज हानि (एवाईआर) और अन्तःफसल लाभ (आईए) के द्वारा विश्लेषण कर किया गया। सीइवाई, एलइआर, एटीइआर और

के जैसे प्रतियोगी सूचकांकों हेतु पंक्ति लगे बैंगन + पालक (दो पंक्तियों) श्रेष्ठ प्रदर्शन किये। जबकि ए, सीआर, एवाईएल एवं आईए जैसे सूचकांकों के सन्दर्भ में बैंगन + पालक (तीन पंक्तियों) को उत्तम पाया गया। यह पोषक तत्वों, प्रकाश एवं उपलब्ध संसाधनों के लिए बैंगन एवं पालक के मध्य अंतः विषय और अंतः स्पर्शी प्रतियोगिता के कारण हो सकती है। सभी अन्तः फसल प्रणाली के लिए एलइआर, एटीइआर व के मान 1 से अधिक थे। इस निष्कर्ष से पर्यावरण के संसाधनों का बेहतर तरीके से दोहन करने के लिए अंतःफसल का उपयोग लाभ प्राप्त करने हेतु किया जाना चाहिए।

References

Anonymous (2018) Horticulture Statistics at a Glance 2018. Horticulture Statistics Division. Ministry of Agriculture & Farmers' Welfare, Government of India. (www.agricoop.nic.in)

Banik P, Samsal T, Ghosal PK and Bagchi DK (2000) Evaluation of mustard (*Brassica campestris* var. *toria*) and legume intercropping under 1:1 and 1:2 row replacement series system. J Agron Crop Sci 185: 9-14.

Connolly J, Gomab HC and Rahimc K (2001) The information content of indicators in intercropping research. Agric Ecosyst Environ 87: 191-207.

Islam MR, Hossain MF, Mian MAK, Hossain J and Alam MA (2016) Outcome of intercropping garlic with brinjal for the small holder farmers of Bangladesh. Indian J Agric Res 50: 177.

Islam MR, Rahman MT, Hossain MF and Ara N (2014) Feasibility of intercropping leafy vegetables and legumes with brinjal. Bangladesh J Agric Res 39: 685.

Kheroar S and Patra BC (2014) Productivity of maize-legume intercropping system under rainfed situation. Afr JAgri Res 9: 1610-1617.

Koohi SS and Nasrollahzadeh S (2014) Evaluation of yield and advantage indices of sorghum (*Sorghum bicolor* L.) and mungbean (*Vigna radiata* L.) intercropping systems. Int J Adv Biol Biomed Res 2: 151-160.

Kumar S, Sahu RS Koohi SS and Nasrollahzadeh S (2014) Evaluation of yield and advantage indices of sorghum (*Sorghum bicolor* L.) and mungbean (*Vigna radiata* L.) intercropping systems. Int J Adv Biol Biomed Res 2: 151-160.

Painkara SK (2014) Biological and economic evaluation of crops under okra [*Abelmoschus esculentus* (L.) Moench] based intercropping system. Progressive Res 9: 291.

Li L, Sun J, Zhang F, Li X, Yang S and Rengel Z (2001) Wheat/maize or wheat/soybean strip intercropping: I. yield advantage and interspecific interactions on nutrients. Field Crop Res 71: 123-137.

Mc Gilchrist CA (1965) Analysis of competition experiments. Biom 21: 975-985.

Nassab MDA, Amonb T and Kaul HP (2011) Competition and yield in intercrops of maize and sunflower for biogas. Indian Crops Prod 34: 1203-1211.

Rezaei-Chianeh E, Nassab ADM, Shakiba MR, Ghassemi-Golezani K, Aharizad S and Shekari F (2011) Intercropping of maize (*Zea mays* L.) and faba bean (*Vicia faba* L.) at different plant population densities. Afr J Agric Res 6: 1786-1793.

Rodge BM and Yadlod SS (2009) Studies of intercropping in vegetables. Int J Agric Sci 5: 357-358.

Singh RJ, Pande KK, Sachan VK, Singh NK, Sahu RP and Singh MP (2016) Productivity, profitability and energy consumption of potato-based intercropping systems. Int J Veg Sci 22: 190.

Weigelt A and Jolliffe P (2003) Indices of plant competition. J Ecol 91: 707-720.

Willey RW and Osiru DSO (1972) Studies on mixtures of maize and beans (*Phaseolus vulgaris*) with reference to plant population. J Agric Sci 79: 517-529.

Yahuza I (2011) Review of some methods of calculating intercrop efficiencies with reference to the estimates of intercrop benefits in wheat/faba bean system. Int J Biosci 1: 18-30.

Zhang G, Yang Z and Dong S (2011) Interspecific competitiveness affects the total biomass yield in an alfalfa and corn intercropping system. Field Crops Res. Doi: 10.1016/j.fcr.2011.06.006.