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INTERCROPPING ADVANTAGES OF GARLIC (*ALLIUM SATIVUM* L.) UNDER EASTERN HIMALAYAN FOOTHILLS REGION

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ABSTRACT
Present experiment was conducted during winter seasons of 2013-14 and 2014-15 to evaluate garlic based intercropping system for higher productivity and profitability under eastern Himalayan foothills region. Nine different treatment combinations were laid out in Randomized Block Design with three replications. The result revealed that among different treatment combinations, association of garlic and garden pea system found maximum bulb diameter (3.4 cm), number of cloves (18.9/bulb), clove diameter (0.96 cm), bulb yield (4.43 t/ha) and garlic equivalent yield (5.99 t/ha) with maximum land equivalent ratio (1.54), relative crowding coefficient (16.29) and lowest value of competitive ratio (0.75) which might be due to better utilization of resources and less competition between both the component crops. It may be suggested that garlic intercropping with garden pea was more efficient and remunerative than mono cropping of garlic and proved highly productive, biologically efficient which will be very helpful for farmers of the foothills of eastern Himalayan region.

INTRODUCTION

Foothills of eastern Himalayan region is characterised by sandy loam soil, high residual soil moisture and prolong winter that encourages large scale garlic cultivation among the small and marginal farmers. However, lower productivity with poor market return is regular phenomenon for the garlic growers of this zone. Inclusion of intercrops in between garlic rows will act as insurance against total crop failure (Lyocks *et al*., 2013), risk minimization, effective use of available resources, efficient use of labour, erosion control and food security that will subsequently ensure crop stability and assured return (Owuor *et al*., 2002; Addo-quaye *et al*., 2011). Hence there is ample scope to utilize the inter row space of garlic through temporal intensification during initial slow growth period to get more productivity and monetary return from limited and smaller land holdings. Improvement of garlic yield with higher productivity and net return in association with other vegetables has been documented by Ahmad *et al*. (2013) and Noghani *et al*. (2013). However information is still meagre about suitable intercrops in garlic for the zone. Hence considering the facts, present study was undertaken to find out the best suited intercrop among the short duration vegetable and spice crops for intercropping advantages and high economic returns of garlic.

MATERIALS AND METHODS

The field experiment was conducted during winter season (November to March) of 2013-14 and 2014-15 at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundbari, Cooch Behar West Bengal, India (26º 19′ 86" N latitude and 89º 23′ 53"E longitude, 43 meter above mean sea level). The soil was sandy loam in nature, coarse in texture, poor in water holding capacity with low pH. The composite soil samples from all the individual plots for both the years were collected and analyzed before raising of garlic and their intercrops. The chemical properties of the soil of the experimental plots are given in Table 1.

The experiment was carried out by using nine treatment combinations and was laid out in Randomized Block Design (RBD) with three replications. The treatments consisted of T_1-sole garlic, T_2-sole mustard, T_3-sole coriander, T_4-sole garden pea, T_5-sole carrot, T_6-garlic + mustard, T_7- garlic + coriander, T_8-garlic + garden pea, T_9-garlic + carrot. The spacing of garlic, mustard, coriander, garden pea and carrot were kept at 25 x 10 cm, 25 x 10 cm, 20 x 10 cm, 20 x 20 cm and 25 x 10 cm apart respectively. The varieties used for garlic, mustard, coriander, garden and carrot were G-50, B-9, Pant Haritima, Goldie and Nantes respectively. The seeds of the intercrops were sown in 1:1 proportion in the inter rows of garlic. The N, P_2O_5 and K_2O were applied at 60:60:120 Kg/ha in garlic, 20:40:20 Kg/ha each in mustard and coriander, 50:20:40 kg/ha in garden pea and 50:50:75 kg/ha in carrot while in intercropping doses of garlic was received by all the intercrops. The sowing of garlic and its intercrops were done on 12th and 18th of November in 2014 and 2015. Harvesting of mustard and garden pea was completed by 15th and 23rd of February. Harvesting of garlic, coriander and carrot were done on 12th march, 26th February and 7th March respectively during the year 2014 and 19th of March, 2nd of March and 10th of March respectively during 2015. The remaining standard recommended crop management practices were followed as

per the package of practices of the respective crops followed for this zone. The economic yield of different intercrops was converted into garlic equivalent yield (GEY) based on the prevailing market price and it was calculated by the formula as described by Reddy and Reddi (2008)

$$GEY(t/ha) = \text{Yield of garlic} + \frac{\text{Yield of intercrop in a mixed stand x Price of intercrop}}{\text{Price of garlic}}$$

The land equivalent ratio (LER) was calculated as suggested by Willey and Osiru (1979).

LER = " YijYii

Where,

Yij = yield of crop in intercropping system

Yii = yield of the crop in sole cropping system

The relative crowding coefficient (K) was calculated as suggested by Hall (1974).

$$Kab = \frac{YabxZab}{(Yaa - Yab)xZab}$$

Where,

yab = yield of crop in mixed stand,

Yaa = yield of crop in pure stand.

Zab = sown/planting proportion of crop a (in mixed stand with b)

The competitive ratio was calculated by the following formula (Willey, 1979)

CRa = (LERa /LERb) x (Zba/ Zab)

CRb = (LERb /LERa) x (Zab/ Zba)

Where,

LER = land equivalent ratio of the component crops (a and b)

Zab = sown proportion of the crop a (in the mixture with b)

Zba = sown proportion of the crop b (in the mixture with a)

The data for individual year was computed and pooled mean was worked out. The significance of the different sources of variation was tested by Fisher and Snedecor's 'F' test with probability at 0.05% for the determination of least significance at 5% level of significance, the statistical tables formulated by Fisher and Yates (1963). All analyses were performed using INDOSTAT version 8.0 statistical package.

RESULTS AND DISCUSSION

The data presented in Table 2 revealed that intercropping has significantly influenced yield and yield attributes of garlic. Sole cropping of garlic recorded the maximum values for yield (5.05 t/ha) and yield attributes like bulb diameter (3.98 cm), number of cloves (22.67/bulb) and clove diameter (1.13 cm). Absence of intercrops facilitated better utilization of resources and less competition between the plants in sole garlic. These results were in confirmation with Thirumdasu *et al*. (2015) in elephant foot yam based intercropping system with spice crops and Sanwal *et al*. (2006) in ginger based intercropping system with legumes crops. Among different intercrops, garlic and garden pea intercropping system revealed superior yield (4.43 t/ha) and yield attributes like bulb diameter (3.40 cm), number of cloves (18.90/bulb) and clove diameter (0.96 cm) which might be due to better utilization of resources and less competition between both the component crops. Brintha and Seran (2012) also found maximum yield attributes in onion raised with chilli.

Garlic + garden pea intercropping system recorded significantly maximum garlic equivalent yield (Table 2) per hectare (5.99 t/ha) followed by sole garlic (5.05 t/ha). The lowest garlic equivalent yield was observed with garlic + coriander (2.33 t/ha). The maximum values for garlic equivalent yield in garlic and pea intercropping treatment might be due to higher yield of the main crop (garlic) and greater market price of the component crop, garden pea. On the other hand, due to lesser yield of garlic in association with coriander and comparatively lower price of this component crop has led to minimum value for this parameter. In accordance with the findings, raise in the equivalent yield of the system through the provision of intercrop equivalent to the main crop was also reported by Dhandayutha pani *et al*. (2015) and Manorama and Lal (2010).

Table 1: Chemical properties of experimental soil

Particulars	Value	Method employed
pH	5.38	pH meter (Jackson, 1973)
Organic Carbon (%)	0.96	Rapid Titration Method (Walkley and Black, 1934)
Available nitrogen (kg/ha)	172.53	Modified Macro Kjeldahl Method (Jackson, 1973)
Available Phosphorus (kg/ha)	34.04	Bray's No. 1 Method (Jackson, 1973)
Available Potassium (kg/ha)	103.50	Flame Photometer Method (Jackson, 1973)

Table 2: Effect of intercropping on yield parameters of garlic (Pooled mean of two years)

Treatment	Bulb diameter (cm)	No of clove/Bulb	Clove diameter (cm)	Bulb yield (t/ha)	Garlic equivalent yield (t/ha)
Sole garlic	3.98	22.67	1.13	5.05	5.05
Garlic + mustard	1.84	11.42	0.54	3.03	3.40
Garlic + coriander	1.21	9.53	0.40	1.93	2.33
Garlic + garden pea	3.40	18.90	0.96	4.43	5.99
Garlic + carrot	2.20	13.47	0.55	3.40	3.98
SEm ±	0.19	1.18	0.03	0.21	0.31
CD	0.61	3.85	0.11	0.67	1.01

Data related to competition functions of garlic based intercropping system has been presented in Table 3. Among intercropping systems, garlic grown with garden pea recorded maximum land equivalent ratio (1.54) on the other hand garlic + coriander recorded lowest value of land equivalent ratio (1.07). Highest value of land equivalent ratio with garlic + garden pea intercropping system might be attributed to efficient utilization of natural resources like nutrients, space, light, etc as well as component crop having different characteristics like nutrient requirements and shading effects. These results were in line with the findings of Ahlawat *et al*. (2005).

The data pertaining to relative crowding coefficient of garlic based intercropping experiment shown that all the intercropping systems recorded relative crowding coefficient greater than one indicating yield advantage over mono cropping and better land utilization efficiency by the component crops. The interaction between garlic and garden pea (legume) found beneficial in terms of yield and recorded higher relative crowding coefficient value (16.29). In harmony with the same results, garlic + garden pea intercropping system recorded lowest competitive ratio (0.75) whereas garlic + coriander intercropping system found extremely competitive than all other combinations as it revealed by highest competitive ratio (1.78) which might be due to the aggressive competition between component crops. These results were in line with the findings of Meena *et al*. (2008) in cluster bean + sesame intercropping system.

The result of two years experiment suggested that garlic intercropping with garden pea found highly productive, biologically efficient and remunerative than mono cropping which will ensure crop stability and assured higher return to the farmers of the foothills of eastern Himalayan region.

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