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ISSN: 0974-4908
Res. Environ. Life Sci.
9(9) 1122-1124 (2016)

Effect of Intercropping of pigeonpea [*Cajanus cajan* (L.) Millsp.] with gum guar genotypes [C*yamopsis tetragonoloba* (L.) Taub.] at different row proportions

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(Received: November 16, 2015; Revised received: June 03, 2016; Accepted: June 09, 2016)

Abstract: Field experiment was conducted at Agricultural Research Station, Gulbarga during *kharif* season of 2013-14 to study the effect of intercropping of pigeonpea [*Cajanus cajan* (L.) Millsp.] with gum guar genotypes [C*yamopsis tetragonoloba* (l.) Taub.] at different row proportions. The results indicated that, sole crop of pigeonpea recorded significantly higher seed yield (1574 kg ha^{-1}), stalk yield (4712 kg ha^{-1}) and protein yield (345 kg ha^{-1}) as compared to intercropped pigeonpea. Among the gum guar genotypes guar cv.RGC-986 recorded significantly higher number of pods per plant (80.07 plant^{-1}), seed yield (1136 kg ha^{-1}) and stalk yield (2283 kg ha^{-1}) over other gum guar genotypes. Among the intercropping systems, pigeonpea + guar cv. HG-365 in 1:2 row proportions recorded significantly higher pigeonpea equivalent (2001 kg ha^{-1}), LER (1.44), ATER (1.33), gross returns (Rs. 86,050 ha^{-1}), net returns (Rs. 60,437 ha^{-1}) and B: C ratio (3.36) over other intercropping systems. Significantly lower pigeonpea equivalent yield (1502 kg ha-1), net returns and B:C ratio was recorded in pigeonpea+sesame (1:2) intercropping systems. From the present study it can be concluded that pigeonpea + guar cv. HG-365 in 1:2 row ratio can be recommended under rainfed conditions of Karnataka state as it recorded significantly higher pigeonpea equivalent yield, LER, ATER, net returns and B:C ratio.

Key words: Pigeonpea, Gum guar genotypes, Intercropping, LER, ATER

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is one of the protein rich pulse crops of the semi-arid tropics, grown predominantly under rainfed conditions. It occupies an important place in the farming systems adopted by dryland farmers. In Karnataka, it is grown in area of 6.80 lakh ha with a production of 4.80 lakh tones and productivity of 712 kg ha^{-1} (Anon., 2013). The guar or clusterbean (*Cyamopsis tetragonoloba*) is an annual legume and the source of gum. In India, the total guar area is 0.56 million hectares with a production of 0.27 million tones and a productivity of 485 kg per ha (Anon., 2013). It is also known as Gavar, Guwar or Guvar bean. India is the leading producer of guar and guar gum in the world, it shares around 80% production of world and rest 20% comes from Pakistan. In India Rajasthan is the leading producer of the guar seed and guar gum. It contributes around 70 per cent production of India. Intercropping is an age old practice being followed by subsistence farmers to achieve their domestic needs. The main advantage of the intercropping is that the component crops are able to use the growth resources differently and make better overall use of growth resources than grown separately (Willey, 1979).When pigeonpea is grown as a sole crop, it is relatively inefficient because of its slow initial growth rate and harvest index (willey *et al*., 1980); therefore it is grown as intercrop, which helps in efficient utilization of available resources for enhancing the productivity and profit. Hence, the present study was undertaken to identify the performances of guar genotypes with different row proportions as intercrop in pigeonpea.

Material and Methods

The field experiment was conducted on shallow black soils at Agricultural Research Station, Gulbarga, University of Agricultural Sciences; Raichur (Karnataka), during *kharif* season of 2013-14 to study the effect of intercropping of pigeonpea [*Cajanus cajan* (L.) Milsp.] with gum guar genotypes [C*yamopsis tetragonoloba* (L.) Taub.] at different row proportions. The experiment consisted of fourteen treatments *viz.,* T_1: Sole Pigeonpea, T_2 : Sole guar cv. HG-365, T_3 : Sole guar cv. HG-563, T_4 : Sole guar cv.RGC-986, T_5 : Sole guar cv. RGC-1031, T_6 : Pigeonpea + guar cv. HG-365 (1:1), T_7 : Pigeonpea + guar cv. HG-563 (1:1), T_8 :Pigeonpea + guar cv. RGC-986 (1:1), T_9 : Pigeonpea + guar cv. RGC-1031 (1:1), T_{10}:Pigeonpea + guar cv. HG-365 (1:2), T_{11}:Pigeonpea + guar cv. HG-563 (1:2), T_{12}:Pigeonpea + guar cv. RGC-986 (1:2), T_{13}:Pigeonpea + guar cv. RGC-1031 (1:2) and T_{14}:Pigeonpea + sesame (1:2) as a check. The experiment was laidout in a randomized complete block design with three replications. The soil of the experimental field was clay loam having organic carbon 0.49%, available nitrogen 230 kg ha^{-1}, phosphorous 30 kg ha^{-1} and potash 635 kg ha^{-1} and EC of 0.2 dS/m with pH 8.30. Bold and healthy seeds of both crops were selected and were treated with capton 2.0 g per kg of seed. Later, the seeds were inoculated with suitable *rhizobium* strains and dried in shade before sowing. The pigeonpea seeds were hand dibbled and guar seeds sown as line sowing on 13-07-2013, at 90 cm row spacing for pigeonpea + guar intercropping system. The recommended dose of fertilizers (NPK kg ha^{-1}) was given for all the component crops (Pigeonpea- 25:50:00 and gum gaur 20:40:00) in the form of urea and diammonium phosphate as a basal dose. In case of intercropping treatments, the fertilizers were applied in proportionate to the sole optimum population for main crop and intercrops separately. Weeding and plant protection measures were undertaken as per need of the crops; the required plant population was maintained. Various growth parameters at 30, 60, 90, 120 DAS and at harvest were recorded. The crops were harvested at their physiological maturity. At the time of sowing adequate moisture was present in the soil. During the cropping period (2013), the mean annual rainfall was 703 mm. July month received a maximum rainfall of 228 mm the maximum temperature was 37.69 °C in December and minimum was 13.97 in October. The mean relative humidity fluctuated between 52.5 per cent in March to 73 per cent in September. Fischer's method of analysis of variance was used for analysis and interpretation of the data as outlined by Gomez and Gomez (1984).

Results and Discussion

Pigeonpea productivity: Seed yield of pigeonpea was significantly influenced due to various treatments comprising of sole pigeonpea, sole guar cultivars and intercropping of pigeonpea and guar cultivars with different row proportions (Table 2). Sole pigeonpea recorded significantly higher seed yield (1574 kg ha^{-1}), stalk yield (2283 kg ha^{-1}), husk yield (787 kg ha^{-1}), harvest index (22.25%) and protein yield (345 kg ha^{-1}) than all other treatments. All the intercropped treatments recorded significantly lower seed yield. With respect to yield attributing characters of pigeonpea, number of pods per plant (185.4), seed yield per plant (41.17 g) and 100 seed weight (9.83 g) were significantly higher in sole crop of pigeonpea compared to intercropped pigeonpea (Table 1). The significant increase in seed yield of sole pigeonpea was mainly attributed to minimum competition for moisture, nutrients and space. Similar results observed in pigeonpea + soybean intercropping system by Kedar Prasad and Yadav (2001) and in pigeonpea + soybean intercropping system by Gupta and Rathore (1995).

System productivity: Pigeonpea equivalent yield differed markedly among the treatments comprising of pigeonpea, gum guar cultivars with different row proportions of gum guar and pigeonpea (Table 3). Significantly higher pigeonpea equivalent yield (2001 kg ha^{-1}) was obtained in pigeonpea+guar cv. HG-365 in 1:2 row proportions than rest of the treatments. The higher pigeonpea equivalent yield was due to higher seed yield of pigeonpea and guar in intercropping system and higher market price of both the crops. The results are in line with the findings of Goyal *et al.* (1991), Singh and Singh (1994) and Sharma *et al.* (1998), Rathod *et al.* (2004) and Shanmugam

Table-1: Yield parameters of pigeonpea as influenced by different row proportions of gum guar genotypes

Treatments	No. of pods/plant	Pod wt. (g plant^{-1})	Seed yield /plant (g)	100 seed wt. (g)
T_1	185.4	70.55	41.17	9.83
T_2	-	-	-	-
T_3	-	-	-	-
T_4	-	-	-	-
T_5	-	-	-	-
T_6	179.2	65.18	36.75	9.78
T_7	161.8	61.58	34.00	9.67
T_8	170.4	62.99	33.83	9.70
T_9	155.6	59.11	34.50	9.61
T_{10}	165.2	64.22	33.75	9.26
T_{11}	150.4	58.34	32.17	9.38
T_{12}	153.2	60.48	31.25	9.38
T_{13}	154.8	61.22	30.75	9.40
T_{14}	148.2	57.86	28.50	9.23
S. Em.±	4.8	1.99	0.13	0.14
C.D. at 5%	14.2	5.90	0.38	0.40

Table-2: Seed yield, stalk yield, husk yield, harvest index, protein content (%) and protein yield (kg ha^{-1}) of pigeonpea as influenced by different row proportions of gum guar genotypes

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Husk yield (kg ha^{-1})	Harvest index (%)	Protein content (%)	Protein yield (kg ha^{-1})
T_1	1574	4712	787	22.25	21.91	345
T_2	-	-	-	-	-	-
T_3	-	-	-	-	-	-
T_4	-	-	-	-	-	-
T_5	-	-	-	-	-	-
T_6	1464	4660	732	21.35	21.72	318
T_7	1326	4315	663	21.03	21.61	287
T_8	1382	4455	691	21.17	21.04	291
T_9	1273	4183	637	20.89	21.30	271
T_{10}	1345	4363	673	21.08	21.02	283
T_{11}	1138	3830	566	20.48	21.15	239
T_{12}	1169	3923	585	20.59	20.77	243
T_{13}	1176	3940	588	20.62	20.84	245
T_{14}	1132	3820	564	20.46	20.95	236
S.Em.±	50	122	28	0.59	0.45	10
C.D. at 5%	149	363	83	NS	NS	28

Table-4: Economics of pigeonpea + gum guar intercropping systems as influenced by different row proportions of gum guar genotypes

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1	22622	67682	45060	2.99
T_2	15772	48285	32513	3.06
T_3	15772	50895	35123	3.23
T_4	15772	51120	35348	3.24
T_5	15772	39960	24188	2.53
T_6	25448	82122	56674	3.23
T_7	25448	76683	51235	3.01
T_8	25448	79721	54273	3.13
T_9	25448	68734	43286	2.70
T_{10}	25613	86050	60437	3.36
T_{11}	25613	77664	52051	3.03
T_{12}	25613	80642	55029	3.15
T_{13}	25613	73608	47995	2.87
T_{14}	25785	64576	38791	2.50
S.Em.±	-	2740	1859	0.11
C.D. at 5%	-	7960	5402	0.34

Table-3: Pigeonpea equivalent yield, Land equivalent ratio (LER) and Area time equivalent ratio (ATER) of pigeonpea + gum guar intercropping under different row proportions

Treatments	Pigeonpea seed yield (kg ha^{-1})	Guar seed yield (kg ha^{-1})	Pigeonpea equivalent yield (kg ha^{-1})	LER	ATER
T_1	1574	-	1574	1.00	1.00
T_2	-	1073	1123	1.00	1.00
T_3	-	1131	1184	1.00	1.00
T_4	-	1136	1189	1.00	1.00
T_5	-	888	929	1.00	1.00
T_6	1464	426	1910	1.33	1.25
T_7	1326	437	1783	1.23	1.16
T_8	1382	451	1854	1.28	1.20
T_9	1273	311	1598	1.16	1.09
T_{10}	1345	627	2001	1.44	1.33
T_{11}	1128	648	1806	1.29	1.18
T_{12}	1169	675	1875	1.34	1.23
T_{13}	1176	512	1712	1.32	1.22
T_{14}	1132	265	1502	-	-
S.Em.±	50	37	65	0.04	0.03
C.D. at 5%	149	109	191	0.12	0.08

In Table 1 to 4 Treatments: T_1- Sole Pigeonpea; T_2 - Sole Guar Cv. HG-365; T_3 - Sole Guar Cv. HG-563; T_4 - Sole Guar Cv.RGC-986; T_5 - Sole Guar Cv. RGC-1031; T_6 - Pigeonpea + Guar Cv. HG-365 (1:1); T_7 - Pigeonpea + Guar Cv. HG-563 (1:1); T_8 - Pigeonpea + Guar Cv. RGC-986 (1:1); T_9 - Pigeonpea + Guar Cv. RGC-1031 (1:1); T_{10} -Pigeonpea + Guar Cv. HG-365 (1:2); T_{11}- Pigeonpea + Guar Cv. HG-563 (1:2); T_{12} -Pigeonpea + Guar Cv. RGC-986 (1:2); T_{13}- Pigeonpea + Guar Cv. RGC-1031 (1:2); T_{14}-Pigeonpea + sesame (1:2)

(2008), wherein pigeonpea + sesame intercropping system recorded higher pigeonpea equivalent yield over sole pigeonpea. Dubey *et al.* (1991) and Kedar prasad and Yadav (2001) reported higher pigeonpea equivalent yield in pigeonpea + soybean intercropping system than sole pigeonpea. The lower pigeonpea equivalent yield (1123 kg ha^{-1}) was recorded in sole guar cv. HG-563 in sole as well as intercropping with pigeonpea in 1:1 row proportion. This could be attributed to absence of pigeonpea in sole guar and lower guar population in 1:1 row proportion of pigeonpea+guar intercropping system. The land equivalent ratio (LER) differed significantly (Table 3) due to intercropping treatments.All the intercropping treatments recorded higher LER values than sole crops (pigeonpea/ gum guar). The significantly higher LER was recorded when guar cv. HG-365 intercropped with pigeonpea in 1:2 row proportion (1.44). The higher LER values in the above intercropped treatments were due to higher yield of component crops in relation to their sole crops. This was evident by higher combined seed yield per plant of both the crops per unit area (Table 3). The higher combined seed yield could in turn related to the fact that component crops differed in utilization of growth resources and converting them more efficiently into yield components resulting in higher yield per plant and yield per unit area. Similar results were also reported by Subbareddy and Venkateshwarlu (1992), Singh and Singh (1994), Narkhede and Katare (1998) and Arjun Sharma and Guled (2012).

Similar to LER, the area time equivalent ratio (ATER) also showed significant variations among the treatments (Table 3). All the intercropped treatments recorded higher ATER values than sole crops. Among the intercropping treatments, significantly higher ATER values were recorded in guar Cv. HG-365 intercropped with pigeonpea in 1:2 row proportions (1.33) than other intercropping treatments. The lower ATER values were recorded in Guar Cv. RGC-1031 intercropped with pigeonpea in 1:1 row proportion. The variations in ATER values in intercropping treatments could be attributed to higher productivity per unit area per unit time. Similar results were also reported by Pujari (1996) in pigeonpea + soybean (2:2) and Patil (2003) in little millet + pigeonpea (4:2) intercropping systems and Arjun Sharma and Guled (2012) in pigeonpea + greengram (1:2) intercropping system.

Economics: Significant differences were observed with respect to gross return and net return among the treatments comprising of gum guar cultivars and row proportions of pigeonpea and gum guar (Table 4). Significantly higher gross return (Rs.86,050 ha^{-1}) and net return (Rs. 60,437 ha^{-1}) were recorded in pigeonpea intercropped with guar cv. HG-365 at 1:2 row proportions followed by pigeonpea intercropped with guar cv. HG-365 at 1:1 row proportions (Rs. 82,122 and Rs. 56,674 ha^{-1} respectively). The lower gross return (Rs.39, 960 ha^{-1}) and net return (Rs. 24,188 ha^{-1}) was recorded in sole guar cv. RGC-1031. Significantly higher gross return and net return in the above treatments were due to higher yield levels of both crops and higher market price of pigeonpea and gum guar crops. Similar results have been reported earlier by Goyal *et al.,* 1991; Verma and Warsi, 1997; Sharma *et al.,* 1998; Jain *et al.,* 2001 and Hanumanthappa and Shivraj, 2003 in pigeonpea + sesame intercropping system at different row proportion.

The B: C ratio also followed similar trend as that of gross and net returns. The pigeonpea intercropped with guar cv. HG-365 at 1:2 row proportions recorded significantly higher B: C ratio (3.36) followed by pigeonpea intercropped with guar cv. HG-365 at 1:1 row proportion (3.23). Significantly lower B: C ratio was recorded in pigeonpea intercropped with sesame at 1:2 in row proportion (2.50). The variations in B: C ratios were due to the variations in gross return and cost of cultivation. The results are also in tune with the findings of Satish Kumar *et al.* (2003), Rathod *et al.* (2004), Shanmugam (2008) and Arjun Sharma and Guled (2012) in pigeonpea and greengram intercropping system.

It could be concluded that intercropping of pigeonpea with gum guar genotypes cv. HG-365 at 1:2 and 1:1 row proportions recorded significantly higher pigeonpea yield, pigeonpea equivalent yield, net returns and B:C ratio as compared to farmers practice i.e., pigeonpea+sesamum in 1:2 row proportions.

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