Int.J.Curr.Microbiol.App.Sci (2017) *6*(6): 2633-2647

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 6 (2017) pp. 2633-2647**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.606.314

Agronomic Management of Cowpea for High Grain Yield and Sustainable Agriculture in Western Indo-Gangetic Plain of India

Guriqbal Singh*, Hari Ram and Navneet Aggarwal

Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana 141004, India
*Corresponding author

Keywords

Crop residues, Nitrogen, Sowing time, *Vigna unguiculata*, *Vigna radiata*.

Article Info

Accepted:
26 May 2017
Available Online:
10 June 2017

ABSTRACT

Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L.) is the major cropping system in western Indo-Gangetic Plain of India. This system is very exhaustive and there is a need to include a leguminous crop in this system for sustainable agriculture. Field experiments were conducted for two years to explore the possibility of growing cowpea [*Vigna unguiculata* (L.) Walp.] and mungbean [*Vigna radiata* (L.) Wilczek] during March/April to June (the period available after harvesting of winter-season crops such as wheat and Brassica and before transplanting and sowing of rainy season crops) and the potential contribution of their crop residues for succeeding crops. Although grain yields were higher from 20 and 30 March sowings than 10 and 20 April sowings, the cowpea crop sown on 20 April produced acceptable yields compared with keeping the fields vacant. Cowpea produced higher grain and straw yields than mungbean. At maturity, after collecting the grain, the aboveground straw yields of cowpea varied from 2817 to 3940 kg ha^{-1}, containing an estimated 34-48 kg N ha^{-1}, which could be utilized by the succeeding crop. We conclude that cowpea may not only provide high grain yields, but also help in improving the soil health.

Introduction

The Indo-Gangetic Plain (IGP) covers a wide area in four countries, namely, Bangladesh, India, Nepal and Pakistan. In India, the IGP covers an area of about 44 million ha from 21°31′ to 32°20′ N and 73°16′ to 89°52′ E, which includes the states of Punjab, Haryana, Delhi, Uttar Pradesh, Uttrakhand, Bihar and West Bengal and small pockets of Jammu and Kashmir, Himachal Pradesh and Rajasthan (Ali *et al.*, 2000). Punjab, Haryana and western Uttar Pradesh, which form the western part of the IGP, are the food basket of India where mainly rice (*Oryza sativa*) and wheat (*Triticum aestivum*) are grown, greatly helping in achieving food sufficiency in India. Due to the development of high yielding irrigation and fertilizer responsive varieties, creation of irrigation facilities, mechanization and assured procurement at remunerative prices, the rice and wheat crops have found favour among farmers, with the result that the area planted to other crops, including grain legumes, has decreased drastically.

Rice and wheat, being cereals and high yielders, have exhausted the soils. The soil fertility in the region is declining. Each tonne of rice removes 47 (20+3+24) kg NPK and each tonne of wheat removes 42 (18+3+21) kg NPK (Patro *et al.,* 2005). Despite high use of fertilizers (NPK), i.e. 250, 207 and 183 kg ha^{-1} in Punjab, Haryana and Uttar Pradesh, respectively (Anonymous 2013), soil fertility is declining and the crop yield is plateauing. There is a need to improve soil fertility by using organic manures such as farmyard manure (FYM) and green manures. FYM is not available in sufficient quantities as it is used to make cow dung cakes, which serve as fuel. Green manuring with leguminous crops such as *dhaincha* (*Sesbania aculeata*) and sunnhemp (*Crotalaria juncea*) has been found beneficial in improving soil physical properties (Walia *et al.,* 2010), soil fertility (Kumar and Singh 2010; Kumar *et al.,* 2011; Pooniya and Shivay 2011) as well as crop yields (Chaudhary *et al.,* 2011; Mahajan *et al.,* 2012). However, the practice of green manuring has not been picked up by the farmers on a large scale, rather it has declined, possibly because the green manure crop does not provide immediate economic benefit to the farmers. However, the production of a grain legume crop, having dual benefits of providing grains and serving as green manure, may find favour among farmers.

In the western parts of IGP, wheat is generally harvested between 1 and 20 April and coarse rice is transplanted in the second fortnight of June and basmati (scented) rice in the month of July. Therefore, after the harvest of wheat and prior to transplanting of rice, the fields remain vacant and other farm resources are not fully utilized. During this idle period, some grain legumes such as cowpea (*Vigna unguiculata*) or mungbean (*Vigna radiata*) could be grown for dual purpose. The studies were, therefore, carried out to find out the possibility of growing grain legumes (cowpea and mungbean) during this period and comparing their productivity levels, potential contribution of crop residues and nitrogen for the succeeding crop.

Materials and Methods

Site characterization

Three field experiments were conducted during the summer of 2008 and 2009 at the Punjab Agricultural University, Ludhiana, India under irrigated conditions. Ludhiana is situated at 30^{o} 56′ N, 75^{o} 52′ E; altitude 247 m.

The soil of the experimental site was loamy sand (Typic Ustochrepts), with pH 8.2, available nitrogen 116 kg ha^{-1}, available phosphorus 16 kg ha^{-1} and available potash 180 kg ha^{-1}. Data on rainfall received and temperature experienced by the crop in the two years are presented in Figure 1.

Treatments and experimental design

Experiment 1, conducted in 2008, studied the effect of four dates of sowing (20 March, 30 March, 10 April and 20 April) and four genotypes [PGCP 3 and PGCP 5 of cowpea (V*igna unguiculata*) and SML 668 and Samrat of mungbean (*Vigna radiata*)] in a split pot design with three replications. Dates of sowing were assigned in the main plots and genotypes were kept in the sub plots. Each sub plot measured 3.5 m × 2.7 m. There were 9 rows of cowpea spaced 0.30 m (seeding rate 50 kg ha^{-1}), whereas mungbean had 12 rows spaced 0.225 m apart (seeding rate 35 kg ha^{-1}).

Experiment 2, conducted in 2009, involved four dates of sowing (20 March, 30 March, 10 April and 20 April) and two genotypes of cowpea (PGCP 3 and PGCP 5). The experiment, having three replications, was conducted in a split plot design by keeping dates of sowing in the main plots and genotypes in the sub plots. Each sub plot measured 5.3 m × 2.4 m. There were 8 rows of cowpea spaced 0.30 m apart.

Experiment 3, planted on 8 April 2008, studied the performance of two genotypes of cowpea (PGCP 3 and PGCP 5) under two row spacings (0.30 and 0.45 m) and three seed rates (40, 50 and 60 kg ha^{-1}). All treatment combinations (2 × 2 × 3 = 12) were tested in a factorial randomized block design with three replications. Each sub plot measured 5.0 m × 1.8 m. There were 6 and 4 rows in the 0.30 m and 0.45 m row spacing, respectively.

Crop husbandry

Pre-sowing irrigation was applied and the seedbed was prepared by cultivating twice and levelling once. At the time of sowing, 16 kg N and 40 kg P_2O_5 ha^{-1} was applied as diammonium phosphate (18% N and 46% P_2O_5). Weeds were controlled by two hand weedings 20 and 40 days after sowing (DAS). During all the experiments, four irrigations were applied to the crop – first at about 20 days after sowing and subsequently at 8-14 days interval depending upon the rainfall. One spray each of Rogar (dimethoate) @ 250 ml ha^{-1} and Thiodan (endosulfan) @ 2 litre ha^{-1} was applied to control thrips and pod borer, respectively.

Observations recorded

Data on days to 50% flowering were recorded when about 50% of the plants had at least one open flower. Data on days to maturity were recorded when the crop attained physiological maturity (when about 80% of the pods matured). At maturity, plant height, number of branches and number of pods were recorded on five randomly selected plants and averaged. Seeds of 10 randomly-selected pods were counted to work out seed number pod^{-1}. The sun-dry weight of 100 seeds was recorded. After sun-drying the harvested crop for four days, the biological yield was recorded on a whole-plot basis and then converted into kg ha^{-1}. Grain yield (sun-dried) was recorded on a whole-plot basis after threshing and converted into kg ha^{-1}. Harvest index is the grain yield/biological yield × 100.

Nitrogen content in straw of mungbean and cowpea at the time of maturity of the crop was estimated to know the amount of nitrogen available for potential use by the succeeding crop.

Statistical analysis

Data were analysed using two-way ANOVA (Cochran and Cox 1967) using CPCS-1 software (Cheema and Singh 1991). Wherever the 'F' ratio was found significant, least significant difference (LSD) values were calculated at P=0.05 for comparing the treatment means.

Results and Discussion

Effect of sowing time

The time to 50% flowering decreased as the sowing time was delayed to 20 April in 2008 (Table 1) and 10 April in 2009 (Table 2). The time to maturity decreased with later planting in 2008, but not in 2009.

In 2008, sowing time had no significant effect on plant height except the latest planting time (20 April) produced significantly (P=0.05) shorter plants than the earlier sowing dates (Table 3). Interaction effects between sowing date and genotype in respect of plant height were significant. Under all sowing dates, cowpea genotypes recorded significantly (P=0.01) higher plant height than mungbean genotypes. Under all sowing dates, pods $plant^{-1}$ were highest in cowpea genotype PGCP 3, which were either significantly (P=0.05) or numerically higher than those recorded under cowpea genotype PGCP 5 or both genotypes of mungbean. Branches $plant^{-1}$ and seeds pod^{-1} were not significantly influenced by the time of planting.

Interaction effects between sowing date and genotype in respect of 100-seed weight were significant (Table 4). The 100-seed weight was significantly (*P*=0.05) higher in cowpea genotypes than in mungbean genotypes under all sowing dates. Furthermore, between mungbean genotypes, SML 668 recorded significantly heavier seeds than Samrat. The crops sown in March produced significantly (*P*=0.01) higher biological yield than those sown in April. Interaction effects between sowing date and genotype in respect of biological yield were significant (*P*=0.05). In case of 20 March, 30 March and 10 April sowings, cowpea genotypes produced significantly higher biological yield than the mungbean genotypes. Mungbean genotype Samrat produced statistically similar biological yield as those by cowpea genotypes. The March sowings produced significantly (*P*=0.01) higher grain yields than the April sowings. Interaction effects between sowing date and genotype in respect of grain yield were significant (*P*=0.01). The cowpea genotype PGCP 3 as well as PGCP 5 when sown on 30 March produced the highest grain yield (1831 kg ha^{-1}), which was, however, at par with those of PGCP 3 and PGCP 5 when sown on 20 March and PGCP 3 when sown on 10 April. In case of mungbean, SML 668 sown on 30 March produced significantly (*P*=0.01) higher grain yield than all other treatment combinations. Harvest index was highest in 20 March sowing, which decreased with delay in sowing, though the differences were non-significant.

In 2009, 30 March sown crop produced tallest plants, which were significantly (*P*=0.01) taller than those of the other three sowing dates (Table 5). Interaction effect between sowing date and genotype was significant (*P*=0.01) with respect to plant height (Table 5). When sown on 30 March, both genotypes produced tallest plants. However, in 20 March sowing, PGCP 5 produced taller plants than PGCP 3. Pods plant^{-1} were highest in 30 March followed by 20 March sowing, both being at par but significantly (*P*=0.05) more than 10 and 20 April sowings (Table 6). Branches plant^{-1}, seeds pod^{-1} and 100-seed weight remained unaffected due to sowing date. Grain yields were highest in case of 30 March sowing followed by 20 March sowing, both being at par but significantly (*P*=0.01) superior to 20 April sowing. Biological yields were high in 30 March and 20 March sowings and significantly (*P*=0.05) lowest in case of 20 April sowing. Harvest index was not influenced significantly.

Performance of genotypes

Mungbean reached 50% flowering earlier than cowpea (Table 1), which was significantly (*P*=0.01) earlier. In mungbean, the genotype SML 668 flowered earlier than Samrat (Table 1) and in cowpea, the genotype PGCP 3 flowered significantly (*P*=0.01 in 2008 and *P*=0.05 in 2009) earlier than PGCP 5 (Tables 1 and 2). The mungbean genotype SML 668 reached maturity significantly (*P*=0.01) earlier than Samrat (Table 1) while the cowpea genotype PGCP 3 reached maturity significantly (*P*=0.01 in 2008 and *P*=0.05 in 2009) earlier than PGCP 5.

Cowpea genotypes were significantly (*P*=0.01) superior to mungbean genotypes in terms of plant height, branches plant^{-1}, pods plant^{-1}, seeds pod^{-1} (Table 3), 100-seed weight, grain yield and biological yield (Table 4). Harvest index was not influenced significantly due to genotypes of cowpea and mungbean. Both genotypes of cowpea were statistically at par in grain yield in all the three experiments (Tables 4, 6 and 7) though PGCP 3 had slightly numerical increase. Similarly, both these genotypes were generally statistically at par in plant growth, yield attributes and biological yields in all three experiments.

Effect of row spacing and seed rate

Row spacing treatments failed to influence plant traits and grain yield of cowpea significantly (Table 7), except biological yield, which was significantly (*P*=0.05) higher in 0.30 m row spacing.

Harvest index was significantly (*P*=0.05) higher in 0.45 m row spacing than in 0.30 m row spacing. With increase in seed rate, grain yield increased significantly (*P*=0.01) up to 50 kg ha^{-1} seed ate. However, other plant traits and biological yield remained unaffected. All interactions with respect to various parameters were non-significant.

Crop straw and its potential nitrogen contribution

Cowpea produced significantly (*P*=0.01) more straw than mungbean in 2008 (Table 8). Delaying the sowing time to 10 and 20 April reduced the straw yield in both 2008 and 2009.

Using values of the average N content (%) in straw at maturity of 1.22% for cowpea (John *et al.*, 1989; and Sharma and Behera 2009b), and 1.16% for mungbean (Sharma and Behera 2009a), we estimated that the cowpea straw contributed about 40 kg N ha^{-1} in 2008 and 35 kg N ha^{-1} in 2009, while mungbean contributed about 30 kg N ha^{-1} in 2008 (Table 9). In Experiment 3, straw yield was considerably higher than in Experiments 1 and 2, with the result that the nitrogen accumulated in the straw was also higher, ranging from 44 to 48 kg N ha^{-1} in the various treatments.

India is the largest producer as well as consumer of pulses [such as chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), fieldpea (*Pisum sativum*), mungbean (*Vigna radiata*), blackgram (*Vigna mungo*), pigeonpea (*Cajanus cajan*), cowpea (*Vigna unguiculata*) etc.] in the world.

In northern India, especially in the western IGP of India (the states of Punjab, Haryana and western Uttar Pradesh), area under pulses had decreased drastically during the last four decades (IIPR 2011).

However, the human population is increasing every year. With the result, per capita availability of pulses has decreased considerably.

Pulses, being rich in protein and minerals, are essential in human diets, especially in India where other protein sources such as meat, egg, fish etc. are not consumed much due to high prices as well as religious beliefs. Therefore, increasing pulses production is a must for meeting their requirement.

There is little scope of increasing area under pulses during rainy and winter season due to severe competition with rice and wheat which provide higher economic returns to farmers. Finding new nitches for growing pulses is, therefore, essential.

Growing of short duration pulses such as cowpea and mungbean offer an opportunity to be raised during the idle period between harvesting of wheat and before transplanting of rice.

Though 30 March sowing produced the highest cowpea grain yields in 2008 (Table 4) as well as in 2009 (Table 6) mainly due to higher number of pods $plant^{-1}$, yet the yield levels obtained with 20 April sowing (1049 and 1173 kg ha^{-1} in 2008 and 1133 kg ha^{-1} in 2009) are also acceptable in comparison to the fields keeping vacant. Sowing time is known to influence grain yield (Yadav 2003; Patel *et al.*, 2005) and green pod yield (Peksen *et al.*, 2002; Mustafa *et al.*, 2011) of cowpea.

Table.1 Time to 50% flowering and maturity in days after sowing in two genotypes of Cowpea and two of mungbean as influenced by sowing date in 2008 (Expt. 1)

Sowing date	Genotype					LSD (*P*=0.05)
	PGCP 3 (Cowpea)	PGCP 5 (Cowpea)	SML 668 (Mungbean)	Samrat (Mungbean)	Mean	
	Days to 50% flowering					
20 March	45	48	34	36	41	Date of sowing=2
30 March	43	45	33	35	39	Genotypes=2
10 April	41	43	32	34	38	Interaction=NS
20 April	40	42	32	33	37	
Mean	42	45	33	35		
	Days to maturity					
20 March	78	82	65	69	74	Date of sowing=1
30 March	78	82	63	68	73	Genotypes= 2
10 April	75	78	60	64	69	Interaction=NS
20 April	70	72	59	62	66	
Mean	75	79	62	66		

Table.2 Time to 50% flowering and maturity in days after sowing in two genotypes of Cowpea as influenced by sowing date in 2009 (Expt. 2)

Sowing date	Genotype			LSD (*P*=0.05)
	PGCP 3	PGCP 5	Mean	
	Days to 50% flowering			
20 March	43	44	44	Date of sowing=2
30 March	42	43	43	Genotypes= 1
10 April	40	42	41	Interaction=NS
20 April	44	46	45	
Mean	42	44		
	Days to maturity			
20 March	77	79	78	Date of sowing=2
30 March	75	80	78	Genotypes= 2
10 April	74	76	75	Interaction=NS
20 April	76	78	77	
Mean	76	78		

Table.3 Plant height, branches plant^{-1}, pods plant^{-1} and seeds pod^{-1} of two genotypes of Cowpea and two genotypes of mungbean as influenced by sowing date in 2008 (Expt. 1)

Sowing date	Genotype					LSD (*P*=0.05)
	PGCP 3 (Cowpea)	PGCP 5 (Cowpea)	SML 668 (Mungbean)	Samrat (Mungbean)	Mean	
	Plant height (cm)					
20 March	69.6	72.1	26.3	28.1	49.0	Date of sowing=6.0
30 March	72.3	70.0	28.8	29.5	50.1	Genotypes= 4.2
10 April	62.3	63.8	30.5	34.0	47.6	Interaction=8.4
20 April	46.2	50.9	32.1	31.0	40.0	
Mean	62.6	64.2	29.4	30.6		
	Branches plant^{-1}					
20 March	7.0	7.3	3.9	3.8	5.5	Date of sowing=NS
30 March	7.3	7.3	4.0	3.9	5.6	Genotypes= 0.5
10 April	7.1	7.1	4.1	3.9	5.5	Interaction=NS
20 April	7.5	7.5	3.8	3.9	5.7	
Mean	7.2	7.3	4.0	3.9		
	Pods plant^{-1}					
20 March	16.5	15.1	11.5	12.2	13.8	Date of sowing=1.7
30 March	18.6	13.7	13.3	11.4	14.2	Genotypes=1.1
10 April	16.3	12.8	10.9	12.6	13.1	Interaction=2.2
20 April	12.8	12.6	9.7	11.0	11.5	
Mean	16.0	13.5	11.4	11.8		
	Seeds pod^{-1}					
20 March	11.3	10.4	8.8	10.3	10.2	Date of sowing=NS
30 March	11.3	10.5	9.7	10.4	10.5	Genotypes=0.4
10 April	11.1	10.8	9.7	10.1	10.4	Interaction=NS
20 April	11.0	10.5	9.2	10.0	10.2	
Mean	11.2	10.6	9.4	10.2		

Table.4 100-seed weight, biological yield, grain yield and harvest index of two genotypes of Cowpea and two genotypes of mungbean as influenced by sowing date in 2008 (Expt. 1)

Sowing date	Genotype					LSD (*P*=0.05)
	PGCP 3 (Cowpea)	PGCP 5 (Cowpea)	SML 668 (Mungbean)	Samrat (Mungbean)	Mean	
	100-seed weight (g)					
20 March	14.40	14.50	5.47	3.20	9.39	Date of sowing=NS
30 March	14.62	14.40	5.50	3.57	9.52	Genotypes= 0.11
10 April	14.43	14.40	5.27	3.40	9.38	Interaction=0.23
20 April	13.93	14.37	5.19	3.20	9.17	
Mean	14.35	14.42	5.36	3.34		
	Biological yield (kg ha^{-1})					
20 March	5385	5174	3775	3814	4537	Date of sowing=365
30 March	5701	5501	4138	4044	4846	Genotypes= 266
10 April	4887	4684	3737	3854	4290	Interaction=533
20 April	3942	3572	3001	3515	3508	
Mean	4979	4733	3663	3807		
	Grain yield (kg ha^{-1})					
20 March	1821	1584	1204	1399	1502	Date of sowing=155
30 March	1831	1831	1646	1045	1588	Genotypes=127
10 April	1626	1523	926	1029	1276	Interaction=254
20 April	1049	1173	947	967	1034	
Mean	1582	1528	1181	1110		
	Harvest index (%)					
20 March	33.93	30.93	32.10	37.00	33.49	Date of sowing=NS
30 March	32.20	33.23	39.90	26.07	32.85	Genotypes=NS
10 April	33.33	32.63	24.97	27.07	29.50	Interaction=8.02
20 April	26.77	33.03	31.73	27.60	29.78	
Mean	31.56	32.46	32.18	29.63		

Table.5 Interaction effect of sowing date and genotype on plant height of Cowpea in 2009 (Expt. 2)

Sowing date	Plant height (cm)		Mean	LSD (*P*=0.05)
	Genotype			
	PGCP 3	PGCP 5		
20 March	43.4	52.2	47.8	Date of sowing=4.0
30 March	55.9	54.6	55.2	Genotype=NS
10 April	46.7	43.1	44.9	Interaction=3.2
20 April	44.2	41.7	43.0	
Mean	47.5	47.9		

Table.6 Plant characters, yield attributes and yield of cowpea as influenced by Sowing date and genotype in 2009 (Expt. 2)

Treatment	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
Sowing date							
20 March	9.4	19.6	13.8	14.9	4468	1428	32.0
30 March	9.2	19.8	13.9	14.5	4599	1520	33.1
10 April	9.0	16.1	13.3	15.2	4088	1297	31.7
20 April	8.8	13.8	12.7	14.6	3643	1133	31.1
LSD (*P*=0.05)	NS	3.3	NS	NS	677	155	NS
Genotype							
PGCP 3	8.8	18.2	13.5	14.9	4186	1369	32.7
PGCP 5	9.4	16.4	13.3	14.8	4213	1320	31.3
LSD (*P*=0.05)	0.6	NS	NS	NS	NS	NS	NS

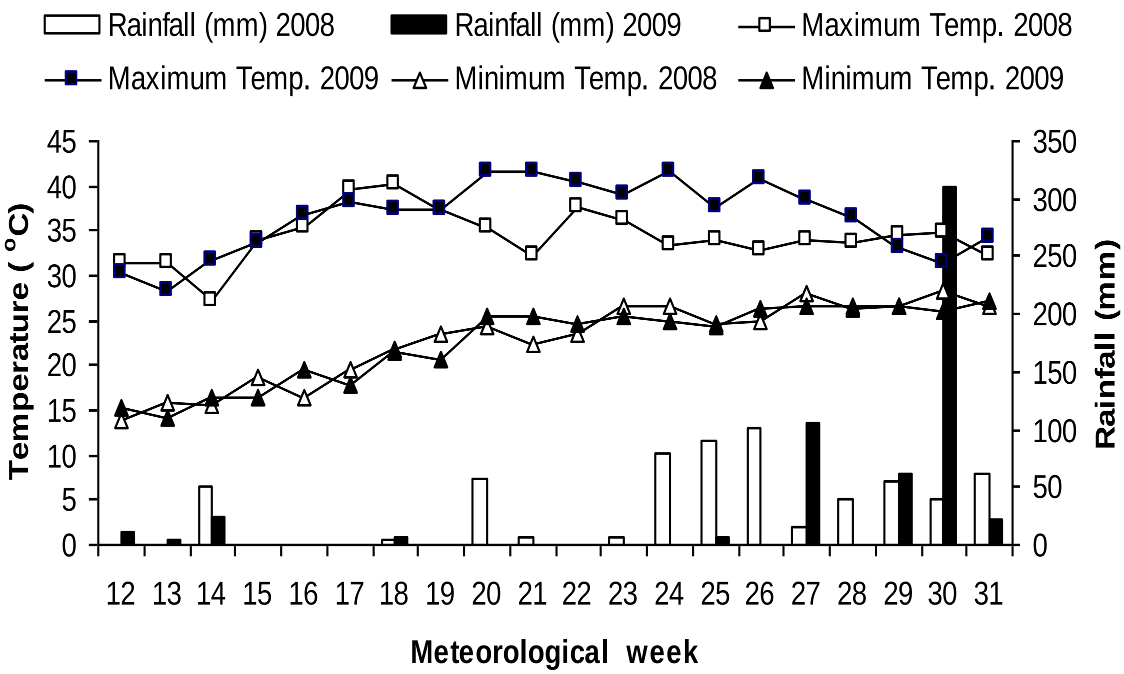
Table.7 Plant characters, yield attributes and yield of cowpea as influenced by row spacing, Seed rate and genotype in 2008 (Expt. 3)

Treatment	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Biological yield (kg ha^{-1}	Grain yield (kg ha^{-1})	Harvest index (%)
Row spacing (m)								
0.30	69.8	7.1	15.3	10.8	14.46	5542	1601	29.0
0.45	69.7	7.4	16.0	10.8	14.49	5267	1636	31.1
LSD (*P*=0.05)	NS	NS	NS	NS	NS	207	NS	1.4
Seed rate (kg ha^{-1})								
40	68.4	7.3	16.6	10.7	14.40	5288	1528	29.0
50	70.8	7.3	15.8	10.9	14.51	5391	1646	30.6
60	70.2	7.2	14.5	10.8	14.51	5534	1682	30.6
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS	94	NS
Genotype								
PGCP 3	70.4	7.2	15.9	10.9	14.46	5487	1653	30.3
PGCP 5	69.2	7.3	15.4	10.6	14.49	5321	1584	29.9
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table.8 Straw yield and nitrogen accumulated in cowpea and mungbean straw at Maturity as influenced by various treatments

Expt. No.	Treatment	Straw yield (kg ha^{-1})	Nitrogen accumulation in straw (kg ha^{-1})
1	Sowing date		
	20 March	3035	36.28
	30 March	3258	38.92
	10 April	3014	35.93
	20 April	2474	29.49
	LSD (*P*=0.05)	452	5.34
	Genotype		
	PGCP 3 (Cowpea)	3397	41.44
	PGCP 5 (Cowpea)	3205	39.10
	SML 668 (Mungbean)	2482	28.79
	Samrat (Mungbean)	2696	31.28
	LSD (*P*=0.05)	321	3.83
2	Sowing date		
	20 March	3040	37.09
	30 March	3079	37.56
	10 April	2791	34.05
	20 April	2510	30.62
	LSD (*P*=0.05)	NS	NS
	Genotype		
	PGCP 3 (Cowpea)	2817	34.37
	PGCP 5 (Cowpea)	2893	35.29
	LSD (*P*=0.05)	NS	NS
3	Genotype		
	PGCP 3 (Cowpea)	3834	46.77
	PGCP 5 (Cowpea)	3738	45.60
	LSD (*P*=0.05)	NS	NS
	Row spacing (m)		
	0.30	3940	48.07
	0.45	3631	44.30
	LSD (*P*=0.05)	188	2.29
	Seed rate (kg ha^{-1})		
	40	3760	45.87
	50	3745	45.69
	60	3853	47.01
	LSD (*P*=0.05)	NS	NS

Fig.1 Meteorological data recorded during 2008 and 2009 in summer season



Though both the genotypes of cowpea produced statistically similar grain yields (Tables 4, 6 and 7) yet due to slightly numerically higher grain yield and earlier maturity (Tables 1 and 2), PGCP 3 may be preferred. The performance of cowpea genotypes may be similar (Wantana *et al.*, 2007) or some genotypes may show superiority over others (Ismail and Hall 2000; Attah *et al.*, 2004; Kumar and Seth 2004; Patel *et al.*, 2005; Ajeigbe *et al.*, 2006; Belane and Dakora 2011) depending upon their genetic makeup.

Seed rates of 50 and 60 kg ha^{-1} produced similar grain yields (Table 7) and row spacings of 0.30 and 0.45 m also did not differ significantly in grain yields, cowpea can, therefore, be sown either at 0.30 or 0.45 m row spacings using a seed rate of 50 kg ha^{-1}. However, Yadav (2003) reported significant effect of row spacing, as row spacing of 0.30 m being at par with 0.45 m, produced higher number of pods per plant and grain yield than 0.60 m spacing. Khan *et al.*, (2002) also reported higher grain yield of cowpea with 0.45 m than 0.60 or 0.75 m row spacing. Singh *et al.*, (1992) revealed that cowpea gave the highest mean green pod yield with 0.30 m × 0.15 m spacing.

Mungbean genotypes produced lower grain yields than cowpea genotypes (Table 4) mainly due to lesser pods plant^{-1}, seeds pod^{-1} (Table 3) and lower 100-seed weight (Table 4). Clearly due to the higher productivity of cowpea than that of mungbean, cowpea needs to be preferred for meeting the pulses demand for human population. Nutritional quality-wise cowpea and mungbean are comparable (Butt and Batool 2010; Keatinge *et al.*, 2011). Mungbean genotypes were earlier in maturity than the cowpea genotypes (Table 1). However, these genotypes of cowpea can fit well during the period available between harvesting of wheat and other winter season crops and transplanting of rice/basmati and other rainy season crops such as maize. When sown on 20 April, the cowpea genotypes tested in the present study matured in 70-72 days in 2008 (Table 1) and 76-78 days in 2009 (Table 2). Slightly longer duration for maturity of 20 April sown crop in 2009 than in 2008 might be due to differences in weather conditions, especially rainfall (Figure 1). Even shorter duration varieties of cowpea maturing in 55 days, with yield of 950 kg ha^{-1}, are available (Bindu *et al.*, 2011), which can even more easily fit in the period available between harvesting of wheat and transplanting of rice. Such short duration varieties of cowpea need to be grown as such and/or also used in breeding programme for developing short duration high yielding varieties.

At maturity, either the crop can be harvested and threshed or pods can be picked up manually (cowpea pods being much longer than those of mungbean can be picked up more easily) and the remaining straw incorporated into the soil. After threshing, quite high amounts of cowpea residues are available (Table 8) which contain high amounts of nutrients including nitrogen (Table 8). These crop residues can be used as green manure before transplanting of rice or sowing other crops. The crop residues are expected to improve physical conditions of the soil (Singh and Malhi 2006) and reduce fertilizer requirements of the succeeding crop (PAU 2014), thereby reducing the cost of cultivation of the cropping system and providing higher income to the farmers. Though at maturity, after collecting grains, mungbean residues can also be used as green manure to supply nitrogen to the succeeding rice crop (Kumari and Reddy 2011), the amount of crop residues of mungbean is much lower than that of cowpea, as found in the present study (Table 8) as well as reported elsewhere (Sharma and Behera 2009a, 2009b; Kumai and Reddy 2011), leaving greater scope of nitrogen contribution by cowpea due to its high straw yield.

Apart from using cowpea grains for human consumption, cowpea can be used not only as fodder (Tekleab and Agarwal 2000; Rao and Northup 2009a) but cowpea grains can also be used to feed animals (Rao and Northup 2009b). Furthermore, cowpea can be grown as a sole crop as well as an inter crop (Bhilare *et al.*, 2001; Singh *et al.*, 2005) and can contribute nitrogen in the form of biological nitrogen fixation (Rusinamhodzi *et al.*, 2006; Nyemba and Dakora 2010; Belane and Dakora 2011; Belane *et al.*, 2011). Cowpea can play an important role in cropping systems not only due to nitrogen fixation or nitrogen contributed through crop residues after harvest but also due to nitrogen in rhizodeposits (which include root exudates, fine roots and root necrosis products accrued in the soil during plant growth) (Laberge *et al.*, 2011). There is, therefore, a need to include cowpea in different cropping systems.

Though cowpea sown on 30 March produced higher grain yield than 20 April sowing, yet 20 April sowing is also acceptable in comparison to keeping the fields vacant. Genotype PGCP 3 showed slight superiority over PGCP 5 in terms of higher grain yield and earlier maturity. The crop may be sown at 0.30 or 0.45 m row spacing using 50 kg ha^{-1} seed rate. The cowpea straw contained 34-48 kg N ha^{-1}, which can be used by the succeeding crop. The present study shows that cowpea can fit well between harvesting of winter season crops and transplanting/sowing of rainy season crops and thereby play an important role in meeting pulse requirement for human population and improving soil health for sustainable agriculture.

Acknowledgement

The authors are thankful to the Punjab Agricultural University, Ludhiana, India for providing funds and other facilities for conducting these trials.

References

Ajeigbe HA, Oseni TO, Singh BB. 2006. Effect of planting pattern, crop variety and insecticide on the productivity of cowpea-cereal systems in Northern Guinea Savanna of Nigeria. Journal of Food, Agriculture and Environment 4:145–150.

Ali M, Joshi PK, Pande S, Asokan M, Virmani SM, Kumar R, Khanpal BK. 2000. Legumes in the Indo-Gangetic Plain of India. In Legumes in Rice and Wheat Cropping Systems of the Indo-Gangetic Plain – Constrains and Opportunities, pp. 35-70 (Eds. C Johansen, JM Duxbury, SM Virmani, CLL Gowda, S Pande and PK Joshi). Patancheru, India: International Crops Research Institute for the Semi- Arid Tropics and Ithaca, New York, USA: Cornell University.

Anonymous. 2013. Agricultural Statistics at a Glance 2013. New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India.

Attah ES, Kalu BA, Adeyemo MO. 2004. Effects of cultivar and plant density on the yield of cowpea [*Vigna unguiculata* (L.) Walp.] In Southern Guinea Savanna Zone of Nigeria. Journal of Sustainable Agriculture and the Environment 6:112–119.

Belane AK, Dakora FD 2011. Photosynthesis, symbiotic N and C accumulation in leaves of 30 nodulated cowpea genotypes grown in the field at Wa in the Guinea savanna of Ghana. Field Crops Research 124:279–287.

Belane AK, Asiwe J, Dakora FD. 2011. Assessment of N_2 fixation in 32 cowpea (*Vigna unguiculata* L. Walp.) genotypes grown in the field at Taung in South Africa, using ^{15}N natural abundance. African Journal of Biotechnology 10:11450–11458.

Bhilare RL, Desale JS, Pathan SH, Toradmal BS, Hiray AG. 2001. Economics of intercropping of soybean and cowpea in sorghum. *Journal* of Maharashtra Agricultural Universities 26:98–99.

Bindu MR, John S, Suja G, Indira M, Vilasini T N. 2011. A high yielding short duration cowpea (*Vigna unguiculata* L.) variety 'Hridya'. Electronic Journal of Plant Breeding 2:506–509.

Butt MS, Batool R. 2010. Nutritional and functional properties of some promising legume protein isolates. Pakistan Journal of Nutrition 9:373–379.

Chaudhary SK, Singh JP, Jha S. 2011. Effect of integrated nitrogen management on yield, quality and nutrient uptake of rice (*Oryza sativa*) under different dates of planting. Indian Journal of Agronomy 56:228–231.

Cheema HS, Singh B. 1991. Software Statistical Package CPCS–1. Ludhiana, India: Department of Statistics, Punjab Agricultural University.

Cochran WG, Cox G M. 1967. Experimental designs. New York: John Wiley & Sons.

IIPR. 2011. Vision 2030. Kanpur, India: Indian Institute of Pulses Research.

Ismail AM, Hall AE. 2000. Semidwarf and standard-height cowpea responses to row spacing in different environments. Crop Science 40:1618–1623.

John PS, Pandey RK, Buresh RJ, Prasad R. 1989. Lowland rice response to urea following three cowpea cropping systems. *Agronomy Journal* 81:853–875.

Keatinge JDH, Easdown WJ, Yang RY, Chadha ML, Shanmugasundaram S. 2011. Overcoming chronic malnutrition in a future warming world: The key importance of mungbean and vegetable soybean. Euphytica 180:129–141.

Khan SM, Bhat MA, Qayoom S, Shah MH, Sidiqque M. 2002. Performance of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) intercropping system under Kashmir conditions. Plant Archives 2:229–231.

Kumar D, Seth R. 2004. Seed yield response of fodder cowpea [*Vigna unguiculata* (L.) Walp.] Varieties to varying seed rate and seed size. Seed Research 32:149–153.

Kumar N, Mina BL, Chandra S, Srivastva AK. 2011. In-situ green manuring for enhancing productivity, profitability and sustainability of upland rice. Nutrient Cycling in Agroecosystems 90:369–377.

Kumar V, Singh AP. 2010. Long-term effect of green manuring and farmyard manure on yield and soil fertility status in rice-wheat cropping system. Journal of the Indian Society of Soil Science 58:409–412.

Kumari CR, Reddy DS. 2011. Sustainable nitrogen management in rice based cropping system. Indian Journal of Agricultural Research 45:93–103.

Laberge G, Haussmann BIG, Ambus P, Hǿgh-Jenson H. 2011. Cowpea N rhizodeposition and it's below ground transfer to a co-existing and to a subsequent millet crop on a sandy soil of the Sudano-Sahelian eco-zone. Plant and Soil 340:369–382.

Mahajan G, Sekhon NK, Sidhu AS. 2012. Response of foliar application of iron and green manuring in dry direct-seeded and transplanted rice (*Oryza sativa*). Indian Journal of Agricultural Sciences 82:373–375.

Mustafa M, Pandey SK, Katara S, Singh A. 2011. Response of phosphorus level and date of sowing on growth and yield of different cultivars of cowpea. Progressive Horticulture 43:155–159.

Nyemba RC, Dakora FD. 2010. Evaluating N_2 fixation by food grain legumes in farmers' fields in three agro-ecological zones of Zambia, using ^{15}N natural abundance. Biology and Fertility of Soils 46:461–470.

Patel IC, Patel BS, Patel MM, Patel AG, Tikka SBS. 2005. Effect of varieties, levels of irrigation and dates of sowing on yield and monetary returns of summer cowpea under North Gujarat agro-climatic condition. Indian Journal of Pulses Research 18:217–221.

Patro H, Mahapatra BS, Sharma GL, Kumar A. 2005. Total productivity, nitrogen, phosphorus and potassium removal and economics of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system with integrated nitrogen management in rice. Indian Journal of Agronomy 50:94–97.

PAU. 2014. Package of Practices for Kharif Crops of Punjab. Ludhiana, India: Punjab Agricultural University.

Peksen A, Peksen E, Bozoglu H. 2002. Effects of sowing dates on yield and quality of cowpea (*Vigna unguiculata* L. Walp.) genotypes grown in greenhouse. Acta Horticulturae 579:351–354.

Pooniya V, Shivay YS. 2011. Effect of green manuring and zinc fertilization on productivity and nutrient uptake in basmati rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* 56:28–34.

Rao SC, Northup BK. 2009a. Capabilities of four novel warm-season legumes in the southern great plains: biomass and forage quality. Crop Science 49:1096–1102.

Rao SC, Northup BK. 2009b. Capabilities of four novel warm-season legumes in the southern great plains: Grain production and quality. Crop Science 49:1103–1108.

Rusinamhodzi L, Murwira HK, Nyamangara

J. 2006. Cotton-cowpea intercropping and its N_2 fixation capacity improves yield of a subsequent maize crop under Zimbabwean rain-fed conditions. Plant and Soil 287:327–336.

Sharma AR, Behera UK. 2009a. Nitrogen contribution through *Sesbania* green manure and dual-purpose legumes in maize-wheat cropping system: Agronomic and economic considerations. Plant and Soil 325:289–304.

Sharma AR, Behera UK. 2009b. Recycling of legume residues for nitrogen economy and higher productivity in maize (*Zea mays*)–wheat (*Triticum aestivum*) cropping system. Nutrient Cycling in Agroecosystems 83:197–210.

Singh AK, Lal M, Srivastava TK. 2005. Enhancing productivity and sustainability of sugarcane plant-ratoon system through planting geometry, dual-purpose legume intercropping and nitrogen nutrition. Indian Journal of Agronomy 50:285–288.

Singh B, Malhi SS. 2006. Response of soil physical properties to tillage and residue management on two soils in a cool temperate environment. Soil and Tillage Research 85:143–153.

Singh D, Sandhu KS, Saimbhi MS, Singh D. 1992. Effect of plant spacing on the pod yield of cowpea cv. Cowpea 263. Journal of Research, Punjab Agricultural University 29:345–346.

Tekleab T, Agarwal IS. 2000. Effect of variety and seed rate on yield, nutrient composition and dry matter digestibility of cowpea fodder. Indian Journal of Animal Nutrition 17:279–283.

Walia MK, Walia SS, Dhaliwal SS. 2010. Long-term effect of integrated nutrient management of properties of Typic Ustochrept after 23 cycles of an irrigated rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L.) system. Journal of Sustainable Agriculture 34:724–743.

Wantana S, Sinsiri N, Silapanont M, Seedasod S. 2007. Effect of sowing distances on edible pod yields and yield components of three vegetable cowpea cultivars (*Vigna unguiculata* L. Walp.) Sesquipedalis subspecies, grown in Northeast Thailand. Pakistan Journal of Biological Sciences 10:4069–4074.

Yadav GL. 2003. Effect of sowing time, row spacing and seed rate on yield of cowpea under rainfed condition. Indian Journal of Pulses Research 16:157–158.

How to cite this article:

Guriqbal Singh, Hari Ram and Navneet Aggarwal. 2017. Agronomic Management of Cowpea for High Grain Yield and Sustainable Agriculture in Western Indo-Gangetic Plain of India. *Int.J.Curr.Microbiol.App.Sci.* 6(6): 2633-2647. doi: https://doi.org/10.20546/ijcmas.2017.606.314