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EFFECT OF ROW ARRANGEMENTS ON SORGHUM-COWPEA INTERCROPS IN IRRIGATION CONDITIONS

Om Singh[1] and M. R. Verma[2]

[1]Livestock Production & Management Section, ICAR- Indian Veterinary Research Institute, Izatnagar, Bareilly - 243 122 (U.P.), India.

[2]Division of LES & IT, ICAR- Indian Veterinary Research Institute, Izatnagar, Bareilly – 243 122 (U.P.), India.

Abstract

A two years field trial was conducted at Bareilly (U.P.), India to investigate the effect of row arrangements on the yield and productivity of sorghum and cowpea intercrop. The treatments comprised two sole sorghum; one sole cowpea and eight sorghum-cowpea combinations. The treatments were replicated three times in a randomized block design. Forage sorghum intercropped with cowpea at 2:1 row proportion produced higher green forage yield (493.5 and 490.1 q ha^{-1}) followed by sorghum intercropped with cowpea at 3:2 row proportion (458.3 and 450.1 q ha^{-1}) compared to sole and other intercrop treatments. However, sorghum grown in association with cowpea at 1:1 row proportion recorded lower green forage (377.2 and 383.2 q ha^{-1}). Sole sorghum pusachari-recorded at par in green forage with MP chari crop as sole crop as well as in intercropping (476.4 and 481.1 q ha^{-1}), respectively. The sole cowpea recorded higher green forage yield over intercrops grown at different row proportions.

Key words : Sorghum, cowpea, intercrop, yield, fodder

Introduction

Sorghum [*Sorghum bicolor* (L) Moench] a dual purpose crop in India. It is adopted to a wide range of environments. Sorghum is widely produced more than any other crops in other crops in the areas where the moisture stress. However, the productivity of sorghum is limited due to deterioration in soil fertility, shortening of the length of fallow and increasing trends towards continuous cultivation of the cereal mono crop in place of traditional rotation and intercropping system. Cereal legume intercropping is among the approaches that induces productivity of crops. Intercropping system have higher productivity than sole cereal systems in semi-arid area. The reason for yield advantage of intercropping than in the respective sole cropping systems (Berhane *et al*., 2015). Legumes with effective biological nitrogen fixation (BNF) can be grown with less applied N fertilizer appropriate fertilization with respect to type, amount, time and method of fertilizer application can increase the advantage of intercropping (Undie *et al.*, 2012). Due to the rising cost of chemical fertilizers, crop nut uptake and utilization must be most efficient to reduce cost of production and achieving higher profit. Hence, intercropping legumes with cereals is particularly important in countries where the cost of N fertilizer is and/or availability of fertilizer is limited. Legumes with effective biological nitrogen fixation (BNF) can intercropped with cereals with less applied N fertilizer to overcome this problem.

Intercropping can be described as the growing of two or more crops simultaneously on the same field. The farmers have developed and improved on traditional systems of mixed cropping but they have maintained relative yield stability at low yield level. Yield could be improved if optimum cropping patterns, crop growth resource requirements and adopted varieties are selected. However the depression is yield of cereal /legume. A fundamental understanding of how intercrops captures and resources would provide a scientific basis for recommending appropriate crop combinations for intercropping (Oseni and Aliyu, 2010).

The livestock population of India 190.9 million cattle, 108.7 million buffalo, 65.0 million sheep, 135.1 million goat and 0.4 million camel etc. (Livestock Census, DADF 2012). This means India houses 15% of global livestock population in its meager 2% geographical area. This is expected deficit of 65 percent of green fodder and 25 percent of dry fodder is expected for Indian livestock by 2015. Cropped area under forage production in India is about 4.4 percent (6.90 m/ha) and there is no scope for expansion of fodder cultivation because of pressure on land for food and cash crops. On a very limited area, cereals and legumes are grown solely for forage production. In this context, intercropping has been recognized as a potential system of forage production which helps in providing balanced diet by accommodating both cereals and legumes, which improves the forage quality. Keeping this in view the present trials was undertaken.

Materials and Methods

A field trial was conducted at LPM section, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly (UP) during 2010-2011 and 2011-12 under dairy washed off water irrigation. The soil of experimental site was silty loam with organic carbon (0.52%), medium in available nitrogen (305 kg ha^{-1}), phosphorus (14.2 $kgha^{-1}$) and potassium (280 kg ha^{-1}). The trial consisting 11 different combination of intercropping forage sorghum MP chari and Pusa chari-5 with cowpea (Pusa komal) viz., 1:1, 2:1, 3:1 and 3:2 row ratio along with three sole crop treatments was laid out in a complete randomized block design with three replications. All the crops were sown at 30 cm rows, inputs were applied based on the area occupied by them. The seed rate was 30 and 40 kg ha^{-1} for sorghum and cowpea, respectively. Sorghum was supplied with 80 : 40:40 and cowpea with a dose of 20:40:40 kg NPK ha^{-1}. All the crops were harvested simultaneously for green fodder during flowering stage (75 days after sowing) of forage sorghum.

Soil sample at a depth of 0-20 cm was taken from five random spots diagonally across the experimental using auger before planting. The collected soil samples were composited to one sample. The bulked samples were air dried, thoroughly mixed and ground to pass 2 mm sieve size before laboratory analysis. Five random plants $plot^{-1}$ from the net plot (2 m × 3 m) were taken to measure leaf area $plant^{-1}$ (cm^2) sorghum, physiologically well performed three leaves $plant^{-1}$ were considered. It was determined at 50% heading using the method described by Sticker *et al*. (1961) as: Leaf area = leaf length of the leaves x maximum width of leaf x 0.75. Where, 0.75 is the correction factor for sorghum. Similarly, leaf area $plant^{-1}$ (cm^2) of cowpea was determined by stacking the leaf laminae of the five sample plants on the table at 50% flowering stage and a cork borer of known area was driven through them to cut out discs. Ten physiological well performed leaves $plant^{-1}$ were sampled. The complete disc where counted and weighed both when fresh and after drying completely. The remaining parts after cutting of discs where combined as per the discs. The weights obtained were used to determine the leaf area as described by Ibrahim *et al*. (2014).

$$A = \left(\frac{a \times n}{w}\right) \times W$$

Where, A = Total leaf area $plant^{-1}$ (cm^2); a = area of individual discs (cm^2); n = number of discs taken; w = weight of dry n discs (gm) and W = Total dry weight of leaves $plant^{-1}$ (gm).

Sorghum component

Plant height of intercropped sorghum was affected due to row arrangement, tallest plant height (234 cm) was recorded in T_1 plots. The lowest plant height (225.4cm) was recorded from T_8 plots. This increment could be due to vital role of more N availability in enlargement of vegetable growth of plant parts. Thus, result correlates with Abebe *et al*. (2013), who reported that there was significant variation in plant height of intercropped maize due to integrated N fertilizer application on maize-soybean intercropping.

Leaf area of sorghum was highly affected by biological N fixation by cowpea but no significant effect of cowpea plant density, interaction effect nor cropping system. The highest leaf area was obtained with T_8 plots (table 2). Leaf area showed increased of N fixation in stimulating enhancing the photosynthesis and metabolic activities of plants, which reflected on the increase in vegetating growth of sorghum (Berhane *et al*., 2015).

Nitrogen fixation by cowpea and the cropping system caused significant response on dry biomass of intercropping with, sorghum and cowpea density (table 2). The vigor of a ground part of sorghum plots due to high N fixation of cowpea enable them to ample solar radiation, which resulted the corresponding increment of photosynthetic rate. This high photosynthesis rate also resulted in higher accumulation of dry matter. Related to this finding, Jat *et al*. (2014) find significant effectof N fertilization on stover yield and yield of maize under maize intercrops.

Cowpea component

Neither of main effects (Cowpea density) nor their intercrops and cropping system caused on plant height of intercropped cowpea (table 3). This might be attributed to less shading effect of sorghum and competition on the intercropped cowpea. This result confirm the finding of Ibrahim *et al*. (2014), who reported that plant height of cowpea did not give significant response to sorghum cowpea intercropping. Abraha (2013) reported that the height between lablab-maize and sole lablab was not statistically affected.

Results and Discussion

Forage sorghum intercropped with cowpea at 2:1 row proportion produced higher green forage yield (493.5 and 490.1 q ha^{-1}) followed by sorghum intercropped with cowpea at 3:2 row proportion (458.3 and 450.1 q ha^{-1}) compared to sole and other intercrop treatments. This was attributed to non-aggressive nature, canopy structure, root system and associated beneficial effects of legume resulting in better utilization of natural resources. However, sorghum grown in association with cowpea at 1:1 row proportion recorded lower green forage (377.2 and 383.2 q ha^{-1}). Oseni and Aliyu (2010) also reported similar line results that the highest yield of sorghum was obtained in the 2:1 sorghum/cowpea row arrangements but not significantly different from 1:1 arrangement while that of cowpea occured in 1:2 sorghum/cowpea row arrangements.

A mean yield reduction in sorghum and cowpea were obtained in sorghum/cowpea intercrops compared to sole crops. It is found that in sorghum/cowpea intercrop, not only the yield of cowpea is depressed by sorghum but cowpea can also depress the yield of sorghum. However, yield reduction due to the intercropping often depended on the crop component ratios, which is part reflect the effect of decreased population density on the yield of component crops. This result is in confirmity with the findings of Karanja *et al*. (2014). Solesorghum pusachari-recorded at par in green forage with MP chari crop as sole crop as well as in intercropping (476.4 and 481.1 q ha^{-1}), respectively. The sole cowpea recorded higher green forage yield over intercrops grown at different row proportions.Generally based on this result of economic analysis, Intercropping cowpea with sorghum was more advantageous than sole crop. In agreement to this result, Solomon *et al*. (2014) reported that the GMV of intercrops was higher than sole maize on maize-soybean intercropping.

Results for mixed green forage yield indicate that sorghum-cowpea intercropping system at 2 : 1 row proportion resulted in superior green forage yield. The higher yields were mainly due to contributionfrom base

Table 1 : Major soil characteristics before planting.

Soil parameter	Unit	Value
Total nitrogen	kg/h	305
Organic matter	%	0.52
Available P	kg/h	14.2
Potassium	kg/h	280
Soil pH	-	7.4
Particle size distribution		
Sand	%	48.00
Silt	%	35.00
Clay	%	17.00

Table 2 : Effect of row arrangements on plant height, leaf area and dry biomass (q/ha) of sorghum under sorghum-cowpea intercropping (Mean of 2 years).

Treatments	Plant height (cm)	Leaf area plant^{-1}(cm^2)	Dry biomass (q ha^{-1})
T_1	234.3	3045.6	66.45
T_2	232.6	3031.2	68.54
T_3	231.2	3000.3	53.45
T_4	228.4	3041.6	53.61
T_5	230.1	3012.2	73.88
T_6	227.6	3200.3	73.31
T_7	226.3	3145.6	71.24
T_8	225.4	3231.2	70.15
T_9	229.4	3185.3	72.95
T_{10}	228.6	3016.6	73.99
T_{11}	-	-	-
$CD_{0.05}$	0.98	7.85	3.30

Table 3 : Effect of row arrangements on plant height, leaf area and dry biomass (q/ha) of cowpea under sorghum-cowpea intercropping (Mean of 2 years).

Treatments	Plant height (cm)	Leaf area plant^{-1}(cm^2)	Dry biomass (q ha^{-1})
T_1	-	-	-
T_2	-	-	-
T_3	160.6	1746.0	18.6
T_4	155.6	1562.6	18.8
T_5	158.3	1643.1	19.5
T_6	162.4	1736.0	12.3
T_7	155.6	1542.6	10.9
T_8	156.4	1663.1	9.5
T_9	161.8	1736.0	7.8
T_{10}	160.2	1542.6	7.1
T_{11}	156.5	1693.1	21.4
$CD_{0.05}$	1.36	7.61	1.96

Table 4 : Effect of row arrangement on green fodder yield (sorghum-cowpea) q/ha under sorghum-cowpea intercropping (Mean of 2 years).

Treatment	Crop row arrangements	Treatment Green Forage yield (q/ha)		
		Sorghum	Cowpea	Mixture
T_1	MP-Chari (sole)	476.4	-	476.4
T_2	Pusa-Chari (sole)	481.1	-	481.1
T_3	MP-Chari + Cowpea (1:1)	377.2	156.8	534
T_4	Pusa Chari + Cowpea (1:1)	383.2	158.3	541.5
T_5	MP Chari + Cowpea (2 :1)	493.5	105.2	598.7
T_6	Pusa Chari + Cowpea (2 : 1)	490.1	103.4	593.5
T_7	MP Chari + Cowpea (3 : 1)	458.2	69.2	527.4
T_8	Pusa Chari + Cowpea (3:1)	450.1	65.1	515.2
T_9	MP Chari + Cowpea (3:2)	479.4	58.5	537.9
T_{10}	Pusa Chari + Cowpea (3:2)	495.2	60.5	535.7
T_{11}	Cowpea (sole)	-	172.6	172.6
$CD_{0.05}$		5.49	5.64	8.93

crop sorghum. Results indicates, yield advantage to the extent of 10 to 20 percent from intercropping system as compared to sole cropping. The results are similar to Berhane *et al*. (2015) and Oseni and Aliyu (2010).

It can be concluded that sorghum cowpea intercropping system at 2:1 row proportion were found to be the best compatible combination for producing higher green forage yields. However, both varieties were found to be at par.

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