

Original Research Article

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## Assessment of Morphological, Physiological and Yield Response of Varagu with Legume Intercropping Planting System

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### ABSTRACT

#### Keywords

Intercropping, Leaf area, Relative water content, Forage, Yield, Productivity

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Many intercropping system have proved to be better than sole crops in terms of yield because intercropping makes better use of one or more agricultural resources both in time and in space. Planting uniformly or nearly uniformly over the land to reduce early interplant competition and increase the rate of solar radiation interception. The principal advantage of intercropping system is the more efficient utilization of soil, water, nutrient and increased productivity compared with each sole crop under rainfed and irrigated ecosystem. Selection of the right small millet intercropping combination is more important in dry land cropping system due to the reason that competition of plant could be minimized not only by spatial arrangement, but also by combining those crops which have best able to exploit soil nutrients. A field study was scheduled to estimate the impact of intercropping varagu with greengram and blackgram cropping system under rain-fed and irrigated situation on photosynthetic efficiency, forage and grain yield at Centre of Excellence in Millets, Athiyandal, Tiruvannamalai. It was done in *Kharif*, 2018 and 2019. Randomized block design was used to conduct this experiment. It has three replications. The aim of this study was to evaluate and compare varagu with greengram and blackgram inter cropping effects on irrigated and rainfed ecosystem on leaf area, relative water content and yield as well as reveal which intercrops better adopts to rainfed cropping systems using these parameters to improve water use efficiency in the production.

### Introduction

Water shortage is threatening crop production and agricultural sustainability (Piao *et al.*, 2010). An added pressure is the severe competition for water resources between agricultural sector and the fast-developing urbanization (Kendy *et al.*, 2007; Poumanyong *et al.*, 2012). Chai *et al.*, (2014) describes various means have been

used to save water in agriculture, including the adoption of regulated irrigation in crop production and the use of innovative water saving practices.

Yin *et al.*, (2015) reported that one of the most effective approaches to improve water use efficiency in the production of field crops. Intercropping has been reported to enhance soil water conservation and reduce run-off

(Sharma *et al.*, 2017), increase the use of available soil water (Yang *et al.*, 2011 and Hu *et al.*, 2017) and improve crop yield for the entire systems and the yield per unit of water supplied (Borghini *et al.*, 2013; Qin *et al.*, 2013), as well as the yield of crops grown the following year in the rotation. Many intercropping systems have proved to be better than sole crops in terms of yield (Zhang *et al.*, 2007) because intercropping makes better use of one or more agricultural resources both in time and in space. Small millets - a group of six crops / minor coarse cereals, namely finger millet (*Eleusine coracana*), little millet (*Panicum miliare*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*Setaria italica*), barnyard millet (*Echinochloa frumentacea*) and proso millet (*Panicum miliaceum*), representing the area grown in that order. These crops have traditionally been the indispensable component of dry farming system. Millets possess several morpho-physiological, molecular and biochemical characteristics which confer better tolerance to environmental stresses than major cereals. Primarily, the short lifecycle of millets assists in escaping from stress as they require 12–14 weeks to complete their life-cycle (seed to seed) whereas rice and wheat requires a maximum of 20–24 weeks.

However, the prevalence of stress conditions and their consequences are circumvented by several traits such as short stature, small leaf area, thickened cell walls, and the capability to form dense root system. Also, the C4 photosynthetic trait is highly advantageous to millets. If we intercrop millets with any legume crop like varagu with blackgram and varagu with greengram then its quality can be made better due to enhanced protein percentage. Varagu cultivated for forage and grain purpose. It is highly tolerant of heat and water shortage. It is good in producing a lot of grain and forage; that's why it is most liked by farmers.

If we intercrop millet with any legume crop then its quality can be made better. Legumes to be very good nitrogen fixers; that's why legumes are considered to be good and if they are grown with non-leguminous crops then it gives good quality grain and forage yield. These are also believed to reduce the cost of nitrogen application as they are already fixing nitrogen from atmosphere (Anil *et al.*, 1998).

It's intercropping with non-leguminous crops not only a reason of increase in production of forage but quality is also enhanced due to high level of protein level than cereals. Cereals are also grown in tropical areas with legumes (Nielsen and Jensen, 2001). This practice is also done in rain fed areas (Agegnehu and sinebo, 2006). We get higher yields in intercropping system than sole system (Lithourgidis *et al.*, 2006).

Growing of legumes with cereals also helps in improving the overall condition of soil by nitrogen fixation (Eaglesham *et al.*, 1981). Fixed nitrogen by the legumes then transferred to cereals growing with legumes that are also much essential to crops (Shen and Chu, 2004). Sowing of mixed seed increases the yield, and quality if done with legumes (Ahmed *et al.*, 2007). Main purpose of this practice is to get higher yield by using all sources that are available at that time which may be not used by a single crop.

## **Materials and Methods**

A field study was scheduled to estimate the impact of intercropping varagu with greengram and blackgram cropping system under rain-fed and irrigated situation at Centre of Excellence in Millets, Athiyandal, Tiruvannamalai. It was done in *Kharif*, 2018 and 2019. Randomized block design was used to conduct this experiment. It has three replications. The experiment is comprised of 8 treatments are as follows:

T <sub>1</sub> – Sole Varagu (45x10 cm)
T <sub>2</sub> – Paired row Varagu (60:30x10 cm)
T <sub>3</sub> – Paired row Varagu + Groundnut (1:1)
T <sub>4</sub> – Paired row Varagu + Black gram(1:1)
T <sub>5</sub> – Paired row Varagu + Green gram(1:1)
T <sub>6</sub> – Sole Varagu + Groundnut (1:1)
T <sub>7</sub> – Sole Varagu + Black gram(1:1)
T <sub>8</sub> – Sole Varagu + Green gram(1:1)

The seed rate for varagu is 10- 12.5 kg / ha, greengram and blackgram for 10 kg/ ha is used. Varagu variety CO 3, Blackgram TNAU (Bg) VBN 7, Greengram VBN (Gg) 2 and Groundnut TMV (Gn) 13 were sown in lines. All agronomic practices are considered as normal for all the treatments except those which were under study.

## Results and Discussion

The data presented in Table 1, 2, 3 and 4 proved that intercropping of varagu with blackgram, greengram and groundnut significantly affected the morphological, physiological and yield parameters such as plant height, leaf area, relative water content, grain yield and straw yield.

### Plant height (cm) of varagu with intercropping on rainfed and irrigated condition

Plants were harvested at different growth stages for growth analysis at vegetative, panicle initiation, grain filling and harvesting stages. The treatment T<sub>7</sub> – Sole Varagu + Black gram (1:1) intercropping performed well under rain-fed condition with less reduction in plant height (78.3 cm) of varagu. In irrigated condition, treatment T<sub>1</sub>– Sole Varagu (45x10 cm) gave maximum height (71.0) cm, due to no competition in this treatment. It is followed by treatment T<sub>7</sub> – Sole Varagu + Black gram (1:1) intercropping which shows plant height (67.3 cm). among the intercropping treatment T<sub>7</sub> – Sole Varagu

+ Black gram (1:1) gave maximum height (78.3 cm) when compare to other treatments. In intercropping, it is revealed that due to intercropping of varagu with legumes, treatment T<sub>7</sub> – Sole Varagu + Black gram (1:1), Blackgram gave maximum height (44.7 cm) under under rainfed condition. Ahmad *et al.*, (2007) also said that there was clear variation in the height of sorghum plants when it was intercropped with other crops.

### Leaf area and relative water contend of varagu with intercropping on rainfed and irrigated condition

Leaf surfaces are the primary photosynthetic organs of the plant, it is sometimes desirable to express growth on a leaf area basis. Leaf area development in annual crops, radiation interception by leaves increases. Since flowering terminates leaf area development, cultural objectives are to maximize photosynthesis by the crop intercepting all or nearly all of the solar radiation. This is an efficient pattern for grain crops, in which the majority of seed weight comes from photosynthesis after flowering. Early growth of individual plants, with little plant-to-plant competition, is described by the relative growth rate, which is based on the rate of dry matter increase in relation to the dry matter weight of the whole plant. The varagu plants treatment T<sub>7</sub> (Sole Varagu with Black gram (1:1)) gave highest leaf area (684.2 cm<sup>2</sup> plant<sup>-1</sup>) under irrigated condition, followed by T<sub>8</sub> [Sole Varagu with Black gram (1:1)] (635.2 cm<sup>2</sup> plant<sup>-1</sup>). The plants of treatment T<sub>4</sub> (Paired row Varagu with Black gram (1:1)) gave maximum relative water content (89%) under rain-fed condition followed by T<sub>7</sub> [Sole Varagu with Black gram (1:1)] (87%). This results shows, T<sub>7</sub> treatment [Sole Varagu with Black gram (1:1)] plant to plant competition is very low; which results in efficient use of solar radiation.

**Table.1** Performance of varagu based intercropping system on Plant height (cm), Leaf area ( $\text{cm}^2 \text{ plant}^{-1}$ ), Relative Water Content (%), Grain yield (kg / ha) and Straw yield (kg / ha) on rain-fed varagu

Treatments	Plant height (cm)	Leaf Area ( $\text{cm}^2 \text{ plant}^{-1}$ )	Relative Water Content (%)	Grain yield (kg/ha)	Straw yield (kg/ha)
T <sub>1</sub> – Sole Varagu (45x10 cm)	69.3	519.1	85	1525	4605
T <sub>2</sub> – Paired row Varagu (60:30x10 cm)	66.3	435.0	83	1502	4458
T <sub>3</sub> – Paired row Varagu + Groundnut (1:1)	65.7	401.1	84	1530	4458
T <sub>4</sub> – Paired row Varagu + Black gram(1:1)	73.0	500.3	89	1584	4739
T <sub>5</sub> – Paired row Varagu + Green gram (1:1)	75.3	478.3	85	1561	4678
T <sub>6</sub> – Sole Varagu + Groundnut (1:1)	68.3	436.5	83	1360	4563
T <sub>7</sub> – Sole Varagu + Black gram (1:1)	78.3	528.8	87	1613	4938
T <sub>8</sub> – Sole Varagu + Green gram (1:1)	71.3	511.1	85	1580	4866
SEd	4.4	5.6	1.3	28	185
CD (P=0.05)	9.6	12.2	2.7	60	400

**Table.2** Performance of varagu based intercropping system on Plant height (cm), Leaf area ( $\text{cm}^2 \text{ plant}^{-1}$ ), Relative Water Content (%), Grain yield (kg / ha) and Straw yield (kg / ha) on irrigated varagu

Treatments	Plant height (cm)	Leaf Area ( $\text{cm}^2 \text{ plant}^{-1}$ )	Relative Water Content (%)	Grain yield (kg/ha)	Straw yield (kg/ha)
T <sub>1</sub> – Sole Varagu (45x10 cm)	71.0	484.1	86	1856	4615
T <sub>2</sub> – Paired row Varagu (60:30x10 cm)	66.7	465.4	88	1822	4602
T <sub>3</sub> – Paired row Varagu + Groundnut (1:1)	62.3	593.0	81	1421	3523
T <sub>4</sub> – Paired row Varagu + Black gram (1:1)	66.0	603.8	83	1551	4143
T <sub>5</sub> – Paired row Varagu + Green gram(1:1)	59.3	568.6	85	1475	3795
T <sub>6</sub> – Sole Varagu + Groundnut (1:1)	62.0	621.4	85	1672	3731
T <sub>7</sub> – Sole Varagu + Black gram (1:1)	67.3	684.2	86	1880	4347
T <sub>8</sub> – Sole Varagu + Green gram (1:1)	64.3	635.2	86	1748	4258
SEd	1.5	3.88	0.84	11	23
CD (P=0.05)	3.3	8.39	1.83	24	51

**Table.3** Performance of varagu based intercropping system on Plant height (cm), Leaf area (cm<sup>2</sup> plant<sup>-1</sup>), Relative Water Content (%), Grain yield (kg / ha) and Straw yield (kg / ha) on intercropping at rain-fed condition

Treatments	Plant height (cm)	Leaf Area (cm <sup>2</sup> plant <sup>-1</sup> )	Relative Water Content (%)	Grain yield (kg/ha)	Straw yield (kg/ha)
<b>T<sub>3</sub> – Paired row Varagu + Groundnut (1:1)</b>	58.0	280.9	83	837	1028
<b>T<sub>4</sub> – Paired row Varagu + Black gram (1:1)</b>	36.3	360.4	87	668	1126
<b>T<sub>5</sub> – Paired row Varagu + Green gram(1:1)</b>	65.3	828.1	85	634	1601
<b>T<sub>6</sub> – Sole Varagu + Groundnut (1:1)</b>	62.3	279.3	82	1064	1341
<b>T<sub>7</sub> – Sole Varagu + Black gram (1:1)</b>	44.7	413.4	85	1210	2084
<b>T<sub>8</sub> – Sole Varagu + Green gram (1:1)</b>	67.3	859.5	83	1125	2678
<b>SEd</b>	4.6	6.1	0.51	18	42
<b>CD (P=0.05)</b>	10.4	13.8	1.15	41	95

**Table.4** Performance of varagu based intercropping system on Plant height (cm), Leaf area (cm<sup>2</sup> plant<sup>-1</sup>), Relative Water Content (%), Grain yield (kg / ha) and Straw yield (kg / ha) on intercropping at irrigated condition

Treatments	Plant height (cm)	Leaf Area (cm <sup>2</sup> plant <sup>-1</sup> )	Relative Water Content (%)	Grain yield (kg/ha)	Straw yield (kg/ha)
<b>T<sub>3</sub> – Paired row Varagu + Groundnut (1:1)</b>	53.7	209.3	81	898	1767
<b>T<sub>4</sub> – Paired row Varagu + Black gram (1:1)</b>	40.3	525.4	83	885	1892
<b>T<sub>5</sub> – Paired row Varagu + Green gram (1:1)</b>	49.0	867.5	82	840	2661
<b>T<sub>6</sub> – Sole Varagu + Groundnut (1:1)</b>	61.0	280.6	83	1131	2330
<b>T<sub>7</sub> – Sole Varagu + Black gram (1:1)</b>	42.7	556.8	84	1215	2375
<b>T<sub>8</sub> – Sole Varagu + Green gram (1:1)</b>	51.7	886.5	80	1159	3331
<b>SEd</b>	0.6	22.8	0.86	15	193
<b>CD (P=0.05)</b>	1.4	51.4	1.93	34	435

**Grain yield (kg/ha) and straw yield (kg/ha) of varagu with intercropping on rainfed and irrigated condition**

Donald (1963) suggested that the greater seed weight and number of seeds per inflorescence at intermediate densities are due to the timing of interplant (between plants) and intra plant

(within a plant) competition. At the widest spacing (lowest plant density), both types of competition are absent during early stages of growth. The treatment T<sub>7</sub> [Sole Varagu with Black gram (1:1)] under irrigated (1880 kg/ha and 1613 kg/ha) and rain-fed (4347 kg/ha and 4938 kg/ha) condition shows the highest value of varagu grain yield and straw yield

than the other treatment. Chellaiah and Earnet (1994) indicated that when sorghum was intercropped with cowpea then their intercrop combinations produced higher yield of fresh and dry matter as compared to their sole combinations. These variations are because of variation in fertility level in soil, change in species selected and prevailing environmental conditions. The treatment T<sub>7</sub> (Sole Varagu with Black gram (1:1)) intercropping produced maximum grain yield and straw yield (1215 kg/ha and 2375 kg/ha) under irrigated and (1210 kg/ha and 2084 kg/ha) under rainfed condition. Marchiol *et al.*, (1992) found that there was increase in the amount of protein contents in intercrop treatments as compared with sole maize.

Climate change and water scarcity may increase number of extreme weather events in the future agricultural crop production. Innovative and effective approaches are needed to alleviate the challenge. In the present study, we determined the sole varagu with blackgram intercropping 1:1 ratio, sharing soil water and nutrients between intercrops during the crop growth period. Using sole varagu with blackgram intercropping 1:1 ratio improves crop productivity through soil water sharing and compensation in water scarcity areas.

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