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Studies on Weed Competition in Intercropping Systems of Pearl Millet (*Pennisetum glaucum* L.) with Legumes as Fodder

AMANDEEP KAUR, BHUPENDRA KOUL[1] AND HINA UPADHYAY*

Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara-144 411 (Punjab), India

**(e-mail: hina.18745@lpu.co.in; Mobile: 90392 39832)*

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ABSTRACT

A field experiment was conducted at the Agricultural Research Farm of Lovely Professional University, Phagwara (Punjab) to study the weed competition in the intercropping system of pearl millet (*Pennisetum glaucum* L.) with legumes as fodder. The experiment was comprised of pearl millet intercropped with cowpea and guar in a randomized block design (RBD) replicated thrice. Yield, growth and quality parameters were recorded during the research work. The growth parameters like plant height, number of leaves and leaf : stem ratio were periodically recorded at 30, 45 and at harvest. Proximate compositions were recorded after the harvest of the crop. Pendimethalin @ 0.75 kg a.i/ha in pearl millet+guar and pendimethalin @ 0.75 kg a.i./ha in pearl millet+cowpea had the highest plant height, number of leaves, leaf : stem ratio, leaf weight, stem weight, crude fiber and dry matter production. The lowest weed count was recorded in pendimethalin @ 0.75 kg a.i./ha (Pearl millet+guar) followed by pendimethalin @ 0.75 kg a.i/ha (Pearl millet+cowpea) as compared to control in both sole and intercropping systems. Thus, it was concluded that pendimethalin @ 0.75 kg a.i./ha was effective in terms of growth and yield of pearl millet intercrops with guar and pearl millet intercrops with cowpea in comparison to other treatments.

Key words: Weed competition, herbicides, intercropping, legume, sustainable weed management

INTRODUCTION

The agricultural crop production is purposely meant to provide sufficient food crops for both human and animal feeding (Diatta *et al.,* 2020). The various agricultural production systems are thus, of great benefit, in upgrading the economy as well as the living standard of rural populations globally (Diatta *et al.,* 2019, Daryanto *et al.,* 2020). In the era 90's, less attention was given to the cultivation of two or more crops in the same piece of land in different parts of the world. The increase in human population and decrease in agricultural lands had gradually become a challenge which triggers farmers to adopt the intercropping system to provide sufficient food for fast-growing world population. The simultaneous planting of more than one crop (intercropping) is an effective strategy that requires less utilization of resources, restores the fertility of the soil and protects soil from degradation (Brooker *et al.,* 2015; Manjunath *et al.,* 2017; Yadav *et al.*, 2017). Planting millet with leguminous crops can help in diversifying crop productivity that provides food and fodder for humans and animal feed in different parts of developing countries (Diatta *et al.*, 2019; Daryanto *et al.,* 2020).

Pearl millet (*Pennisetum typhoideum*) is a vital, extensively cultivated and most durable crop in India with a production area of about 9-10 million ha, accounting for 50% of the global production producing 7-8 million tons of grains per year. It is a tropical crop grown in the arid and semi-arid climate zones with great potential to contribute to food security in many nations of the world (Choudhary *et al.,* 2017). Pearl millet variously classified as *P. glaucum, P. americanum,* or *spicatum,* and known as *bajra* in India. The suitable temperature for better germination of pearl millet is 23 to 32°C. The required optimum rainfall for its production is 500-800 mm/annum. It is drought tolerant crop and grows where water is in scarcity, temperature is high and moisture content is low. Nutritionally, pearl millet consists of carbohydrates, zinc, lipids and proteins. It consists approx. 9 to 13% protein, which is more than rice (7.2%) barley (11.5%), maize (11.1%) and sorghum (10.4%). It also contains approx. 8% fat which is higher than rice, wheat, barley

[1]Department of Biotechnology, Lovely Professional University, Phagwara-144 411 (Punjab), India.

and sorghum. Pearl millet is 40% rich in amino acids, methionine and lysine as compared to maize. Being grown predominantly in humid/ warm rainy season, the crop has been deprived by a number of weeds as they compete with the crop for different resources such as light, nutrient, space and water thereby reducing the yield and quality of the crop. Considering the global utilization of millets for food and nutritional security, understanding the effects of weeds on crop intercropped with legumes will lead to development of appropriate weed management approach in the elimination of weeds in our farms. The present study aimed at evaluating the weed competition in the intercropping system of pearl millet (*Pennisetum glaucum* L.) with legumes as fodder.

MATERIALS AND METHODS

This study was conducted at the Agricultural Research Farm, Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara (Punjab). during the *kharif* season 2019-20. It is located on latitude 29°30'N to 32°32'N, longitude 73°55'E to 76°50'E with 21°C and 250 to 1000 mm as mean annual temperature and rainfall, respectively.

Soil analysis was carried out by collecting samples from 0-15 cm depth in the experimental area before sowing. The samples were collected randomly from six places and made into composite samples. Representative samples were made from the composite sample and later used for analysis. The sample was analyzed for pH, EC, OC and available nutrients (N, P and K).

The experiment was conducted as a randomized block design (RBD) using 10 treatments replicated three times with a plot size of 5 × 4 square meters. The treatments included T_1–Control (sole pearl millet), T_2–Control (pearl millet+cowpea), T_3–Control (pearl millet+guar), T_4–Pendimethalin @ 0.75 kg a.i./ha (sole pearl millet), T_5–Pendimethalin @ 0.75 kg a.i./ha (pearl millet+cowpea), T_6–Pendimethalin @ 0.75 kg a.i./ha (pearl millet+guar), T_7–Control (sole cowpea), T_8–Control (sole guar), T_9–Pendimethalin @ 0.75 kg a.i./ha (sole cowpea) and T_{10}–Pendimethalin @ 0.75 kg a.i./ha (sole guar).

The growth parameters analyzed were plant height (cm), number of leaves per plant, leaf : stem ratio and yield (q/ha). Plant height was measured using a measuring tape in tagged plants in each plot. The number of leaves was counted manually on randomly tagged plants in each plot and the average value was calculated. The fresh forage yield was taken. The data on plant growth parameters were analyzed using ANOVA and means were compared using least significant difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

The treatment pendimethalin @ 0.75 kg a.i./ ha (sole cowpea) T_9 resulted in significantly higher plant height and the lowest was recorded in control at 30 DAS. But at 40 DAS and at harvest pendimethalin @ 0.75 kg a.i./ ha (pearl millet+guar) T_6 followed by pendimethalin @ 0.75 kg a.i./ha (pearl millet+cowpea) T_5 was recorded with higher plant height and the lowest was recorded in control (sole cowpea) T_1 (Table 1). In the cowpea case, the maximum height of the plant was observed in pendimethalin @ 0.75 kg a.i./ha (sole cowpea) T_9, and the lowest was recorded in control (sole cowpea) T_7. In guar, the maximum height was in pendimethalin @ 0.75 kg a.i./ha (sole guar) T_{10}. This was due to the influence of intercropping system which significantly increased plant growth. This finding is similar with that of Choudhary *et al.* (2017) and Diatta *et al.* (2019).

The highest number of leaves was recorded by pendimethalin @ 0.75 kg a.i./ha (pearl millet+guar) T_6 followed by pendimethalin @ 0.75 kg a.i./ha (pearl millet+cowpea) T_5 which was significant ($P<0.05$). The lowest number of leaves was recorded in control (sole pearl millet) T_1 followed by control (sole cowpea) T_7.

On comparing basis, the average mean of individual intercrops, the highest leaf weight was observed for treatment T_6 (0.22 kg/plant) followed by T_5 (0.16 kg/plant) in pearl millet which was significant ($P<0.05$) and the lowest was recorded in T_2 (0.036 kg/plant) under control in intercropping (Table 2). The maximum leaf weight was observed T_9 (0.16 kg/plant) which was significant ($P<0.05$) and lowest was recorded in control in cowpea. The highest leaf weight in the guar crop was observed in T_{10} (0.063 kg/plant) which was significant ($P<0.05$) and lowest in control treatment. This may be both intercrops were collaborated with each other nicely and

Table 1. Effect of pre-emergence herbicides on plant growth, plant height and number of leaves in pearl millet with intercropping (cowpea and guar)

Parameters/Treatments	Plant height (cm)			No. of leaves/ plant		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
T_1	0.36^{abc}	0.85^{a}	1.56^{cd}	4.3^{a}	9.3^{a}	13.0^{a}
T_2	0.31^{a}	0.91^{ab}	1.67^{cde}	4.6^{a}	10.3^{a}	13.3^{a}
T_3	0.31^{a}	0.90^{ab}	1.70^{de}	5.0^{a}	8.3^{a}	12.6^{a}
T_4	0.34^{ab}	0.88^{ab}	1.64^{cd}	5.3^{a}	11.0^{a}	14.6^{a}
T_5	0.32^{a}	1.05^{cd}	1.73^{de}	5.6^{a}	11.6^{a}	15.0^{a}
T_6	0.33^{bc}	1.10^{d}	1.98^{e}	6.0^{a}	12.0^{a}	15.3^{a}
T_7	0.37^{a}	0.98^{bc}	1.13^{ab}	20.9^{a}	40.3^{b}	44.3^{b}
T_8	0.33^{bc}	0.82^{a}	1.00^{a}	32.3^{c}	63.3^{c}	72.6^{d}
T_9	0.39^{ab}	1.04^{cd}	1.18^{bc}	34.6^{c}	43.6^{b}	50.3^{d}
T_{10}	0.34^{c}	0.85^{a}	1.49^{ab}	33.0^{c}	65.6^{c}	73.0^{d}
Significance	S	S	S	S	S	S

DAS – Days after sowing, T_1, T_2, T_3..... T_{10} – Treatments and S – Significance (P≥0.05).
Different superscripts differ significantly.

Table 2. Effect of pre-emergence herbicides on crude fiber in pearl millet with intercropping crops (cowpea and guar)

Parameters/Treatments	Crude fiber (%)	Leaf weight	Stem weight	Leaf : stem ratio	Yield (q/ha)
T_1	4.0^{a}	0.043^{a}	0.37^{a}	0.11^{a}	27.7^{ab}
T_2	4.2^{d}	0.036^{a}	0.42^{a}	0.09^{a}	28.4^{ab}
T_3	4.6^{cd}	0.050^{a}	0.39^{a}	0.12^{a}	24.0^{a}
T_4	4.3^{ab}	0.046^{a}	0.44^{a}	0.10^{a}	33.6^{bcd}
T_5	4.7^{bcd}	0.166^{c}	0.72^{b}	0.22^{bc}	40.3^{de}
T_6	5.0^{cd}	0.220^{d}	0.86^{d}	0.25^{c}	45.5^{e}
T_7	4.5^{bc}	0.053^{a}	0.44^{a}	0.11^{a}	31.7^{bc}
T_8	4.7^{bcd}	0.050^{a}	0.37^{a}	0.13^{a}	26.9^{ab}
T_9	4.8^{cd}	0.106^{b}	0.63^{b}	0.16^{ab}	38.8^{cde}
T_{10}	4.7^{bcd}	0.063^{a}	0.48^{a}	0.13^{a}	33.6^{bcd}
Significance	S	S	S	S	S

DAS – Days after sowing, T_1, T_2, T_3..... T_{10} – Treatments and S – Significance (P≥0.05).
Different superscripts differ significantly.

intercropping influenced the weight of leaf. Leaf weight was maximum in treatments T_6 (0.22), T_9 (0.16) and T_{10} (0.06) with the comparison of herbicidal effect on it and control.

The average mean of the stem weight was recorded highest in treatment T_6 (0.86 kg/ plant) followed by T_5 (0.72 kg/plant) and T_4 (0.44 kg/plant) which was significant and the lowest average mean was observed in control treatments for pearl millet. The average mean stem weight of cowpea was recorded as maximum in treatment T_9 (0.63) which was significant and lowest in control. In guar, stem weight was observed in treatment T_{10} (0.48) but the lowest was recorded in the control treatment. Therefore, the average mean of stem weight at the harvesting stage was recorded as maximum in treatment T_6 (0.86) and T_5 (0.72) for pearl millet. This was because of the increase of yield and plant growth attributes by the effect of adopted herbicide and intercropping system.

The highest leaf : stem ratio at the time of harvest was recorded in treatment T_6 (0.25 kg/ plant) followed by T_5 (0.22 kg/plant) which was significant and the lowest was observed in control for pearl millet. For cowpea, the maximum value of leaf : stem ratio was obtained in treatment T_5 (0.22 kg/plant), whereas it was lowest in the T (control). For guar, the maximum leaf: stem ratio was recorded in T_9 (0.16 kg/plant) which was significant, and the lowest was observed in treatment T_7 (0.11) for control. This result was closely related to Maitra *et al.* (2019).

The maximum yield was recorded at harvest in intercropping than sole cropping. The highest yield was recorded in treatment T_6 (45.5 q/ha) followed by T_5 (40.3 q/ha) which was significant and the lowest was recorded

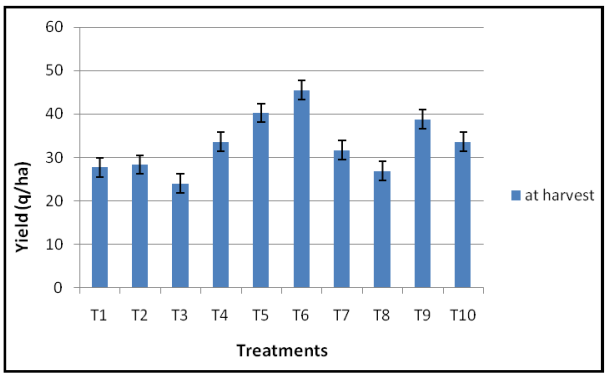

Fig. 1. Effect of pre-emergence herbicides on yield in pearl millet with intercropping crops (cowpea and guar).

in treatment T_3 (24.0) in control for the intercropping system (Fig. 1). The highest yield of sole cowpea was recorded in treatment T_9 (38.8 q/ha) under herbicide which was highly significant and the lowest was recorded in treatment T_7 (31.7 q/ha) in control for sole cowpea. The maximum yield of sole guar was observed from T_{10} at (33.6 q/ha) and lowest in T_8 (26.9 q/ha) in control. This was because of all the growth parameters was obtained highest in the intercropping system under herbicide dose effect and in sole crop under herbicide spray than control. It indicated that growth attributes were highest due to the effectiveness of herbicide in plants. This result was similar to Maitra *et al.* (2019), Diatta *et al.* (2019) and Swaminathan *et al.* (2021).

By comparing sole crop to intercropping, the highest crude fibre content was recorded in T_2 (5.1%) followed by T_6 (5.0%) in pearl millet for an intercropping system which was significant and the lowest was recorded T_1 (4.0%) for sole pearl millet (Table 2). In sole cowpea, the highest crude fibre was obtained in treatment T_9 (5.0%) which was significant. The average mean of crude fibre was recorded in treatments T_2 and T_6 because of pearl millet intercrops with cowpea that showed maximum crude fibre due to intercropping effects on it. The lowest was obtained in treatment T_1 in sole pearl millet for control. Under control, the yield was obtained very less as compared to the herbicidal dose effect, and the growth was also obtained lowest in control under sole crop with compared to herbicide dose effect in the sole crop.

The maximum weed counts (8.43/m^2) followed by (8.06/m^2) were obtained in treatments T_7 and T_8 in sole cowpea and sole guar for control that was significant (Table 3). The minimum weed population was recorded in treatment T_6 (3.66/m^2) followed by T_5 (5.03/m^2) in intercrops with pearl millet for herbicide dose spray. This result was similar to that of Sannagoudar *et al.* (2021). This was because herbicide spray as pre-emergence herbicide to the soil, improved yield and growth of plant due to effective weed management. By weed management, weeds were reduced by effective herbicide (Pendimethalin) dose. This result was similar to that of Habimana *et al.* (2019) and Sannagoudar *et al.* (2021).

The maximum weed dry weight at harvest was recorded in treatment T_8 (9.70 g) followed by T_7 (9.13 g) for control which was moderately significant. The lowest dry weight of weeds was observed in treatment T_6 (4.26 g) followed by T_5 (4.70 g) in herbicide applied plots. This may be because of suppression of weeds under pendimethalin spray in pre-emergence time.

Table 3. Effect of pre-emergence herbicides on weed growth in pearl millet with intercropping crops (cowpea and guar)

Parameters/Treatments	Weed count			Weed dry weight		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
T_1	7.03^{e}	7.76^{e}	7.36^{e}	5.63^{bc}	7.50^{bc}	9.36^{d}
T_2	6.86^{e}	6.93^{de}	6.46^{d}	5.16^{b}	6.63^{b}	7.73^{bc}
T_3	7.03^{e}	7.63^{e}	7.90^{ef}	5.73^{bc}	7.06^{b}	6.83^{b}
T_4	6.10^{d}	7.63^{e}	5.26^{bc}	2.96^{a}	4.00^{a}	4.90^{a}
T_5	4.33^{b}	5.46^{b}	5.03^{b}	2.73^{a}	3.93^{a}	4.70^{a}
T_6	3.63^{a}	4.16^{a}	3.66^{a}	2.56^{a}	3.46^{a}	4.26^{a}
T_7	6.90^{e}	7.86^{e}	8.43^{f}	6.36^{c}	8.20^{cd}	9.13^{cd}
T_8	6.16^{d}	7.83^{e}	8.06^{ef}	6.56^{c}	9.00^{d}	9.70^{d}
T_9	4.43^{b}	5.80^{bc}	5.26^{bc}	3.23^{a}	3.83^{a}	4.56^{a}
T_{10}	5.20^{c}	6.36^{bcd}	5.96^{cd}	3.13^{a}	4.46^{a}	5.06^{a}
Significance	S	S	S	S	S	S

DAS – Days after sowing, T_1, T_2, T_3..... T_{10} – Treatments and S – Significance (P≥0.05).
Different superscripts differ significantly.

It showed that the weeds occurred less in intercropping system under pendimethalin spray. This result is similar to that of Sannagoudar *et al.* (2021).

The soil analysis at harvest significantly resulted in high nitrogen, phosphorus and potassium for pendimethalin @ 0.75 kg a.i./ha (pearl millet+guar) T_6 followed by pendimethalin @ 0.75 kg a.i./ha (pearl millet+cowpea) T_5, respectively, but potassium was higher in T_{10} pendimethalin @ 0.75 kg a.i./ha (sole guar) and lowest was recorded in control treatment in sole crops.

CONCLUSION

The best results were recorded in pendimethalin @ 0.75 kg a.i./ha (pearl millet+guar) followed by pendimethalin @ 0.75 kg a.i./ha (pearl millet+cowpea) followed by pendimethalin @ 0.75 kg a.i./ha (sole cowpea) T_9 and pendimethalin @ 0.75 kg a.i./ha (sole guar) T_{10}. Weeds were recorded high where pendimethalin @ 0.75 kg a. i./ha was not applied. Pearl millet intercrop with guar under pendimethalin dose was recommendable to farmers because its performance throughout the season in growth and quality attributes was highly significant. If farmers would apply pendimethalin @ 0.75 kg a.i./ha in pearl millet+guar and pendimethalin @ 0.75 kg a.i./ha in pearl millet+cowpea, then the quality and yield of fodder could be improved with high scale profit. Among all the treatments, pendimethalin @ 0.75 kg a.i./ha (pearl millet+guar) was recommendable followed by pendimethalin @ 0.75 kg a.i./ha (pearl millet+cowpea) over control (pearl millet+guar) and control (pearl millet+cowpea). The highly significant results for growth parameters like plant height, number of leaves and weight of stem and leaves were observed when herbicide was applied. The quality and the yield of fodder can be improved by use of pendimethalin @ 0.75 kg a.i./ha in both pearl millet+cowpea and pearl millet+guar.

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