



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 1, January 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

9940 572 462

6381 907 438

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Splash Loss, Water Use Efficiency, Root Development, Seed Equivalent Yield and Economics of Pigeon Pea (*Cajanas cajan* L.) based Intercropping System under Rainfed Condition

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ABSTRACT: A field experiment was conducted during two consecutive years in kharif 2015-16 and 2016-17 at Soil Conservation and Water Management Farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur to find out the effect of sorghum (*Sorghum bicolor* L.) based intercropping on splash loss, grain yield, water use, water use efficiency, root development, seed equivalent yield and economics under rainfed condition. The treatments comprised 6 intercropping systems i.e. C₁- sole pigeon pea at 60cm by regular sowing, C₂- sole pigeon pea paired 40/80cm, C₃- Sole sorghum at 45cm by regular sowing, C₄- Sole urdbean at 45cm by regular sowing, C₅- Pigeon pea + sorghum paired sowing at 40/80cm, C₆- Pigeon pea + urdbean paired sowing at 40/80cm and 3 moisture conservation practices i.e. M₁- Control, M₂- Ridging and furrowing in between crop rows after three weeks of planting, M₃- Weeding and hoeing once at 35 days after sowing were assigned in split plot design with three replications. The results revealed that minimum splash loss of 2.90 and 2.97 t ha⁻¹ was observed under sown urdbean by regular sowing (C₄) while maximum splash loss 5.45 and 5.70 t ha⁻¹ was noted under sole pigeon pea by regular sowing (C₁) treatment during experimentation. In case of water use & water use efficiency highest water use measured C₅ treatment while lower values of water use was estimated under C₄ treatment during both the year, in case of moisture conservation practice maximum water use measured in control (C₁) treatment, while minimum in M₂ treatment during both the year of experimentation. Highest water use efficiency was observed under pigeon pea + urdbean paired sowing at 40/80cm in (C₆) treatment being 4.78 and 4.74 kg seed ha⁻¹ mm⁻¹ of water while lowest figures of water use efficiency 3.95 and 4.01 kg seed ha⁻¹ mm⁻¹ of water was recorded under treatment (C₅). In case of net return maximum net return was obtained under treatment (C₆) with pigeon pea + urdbean paired planting at 40/80cm while lowest values was noted under sorghum by regular planting at 45cm under treatment (C₄). In case of moisture conservation practices maximum water use efficiency and net return was observed in ridge and furrowing treatment (M₂) over control while lowest splash loss measured under (M₂) treatment over other treatments under test during both the year of experimentation. As for moisture extraction pattern is concern maximum amount of soil moisture was taken from surface layer (0-25cm depth) by sole urdbean regular planting while lowest from deeper layer (75-100 cm depth) by control treatment.

KEYWORDS: Splash loss, water use, water use efficiency, moisture extraction pattern & sorghum based intercropping



I. INTRODUCTION

An eye opening scenario regarding soil erosion and water scarcity is being a challenging task for concern in the climate changing trend in world. As the days pass, water is becoming scarce even in the area where it was plenty and fertile land is gradually diminishing loss of productivity and shortfall in both food and cash crops are the immediate impacts of soil and water erosion. There is an evidence of stagnation or decline in the food grain productivity even with the continue application of recommended rate of fertilizers. High soil loss and depletion of soil organic matter, erratic rainfall, low soil moisture retention and low water use efficiency are major constraints for low productivity. It is necessary to produce maximum yield per unit area by using available water effectively because irrigation water is diminishing in most parts of the world. Irrigation agriculture would take place under water scarcity condition not only at present but would increase in the future. Emphasis will shift from production per unit of water consumed. About 85 mha cultivated land i.e. 60% of total arable land in India is cultivated under rainfed conditions, characterized by low productivity, low income less employment and higher poverty. Rainfed areas are hotspots of several problems viz., malnutrition, food insecurity, land degradation water scarcity and poor social and institutional infrastructure. In a developing country like India, soil erosion due to water causes 96 Mha of land, which is meanly 68.4% of the degraded lands of the country and threatening productivity and fertility of the soil.

Pigeon pea, sorghum (*Sorghum bicolor* L.) and urdbean are extremely resistant to drought and grown in dry and semi-arid parts of the world. About 80% of pigeon pea, sorghum is cultivated under rainfed sub-tropical climate in India. In these region rainfall varies from 500-900mm. Therefore, it may be feasible and viable agronomic practice for stepping up the production of pulses, oilseeds and cereals from a until of land during a cropping period. Now a day intercropping is receiving greater emphasis in Indian agriculture because of yield advantage especially under adverse weather conditions and substantially increases economics returns. It is the way of growing two or more crops simultaneously on the same piece of land with a definite row pattern. It has been well recognized that intercropping systems designed on principle of scientific base in crop production, hold a great promise in increasing the land productivity under Indian conditions. Significant advantage in land use efficiency, crop productivity and monetary return in intercropping, as compared with sole cropping of component crops have been recorded throughout the length and breadth of the country covering diverse agro-ecological situations. Thus, the intercropping of pigeon pea, sorghum and urdbean having different growth habits canopy adoption and rooting pattern can easily be accommodated with least competition. Considering all above points and need of increasing cereals and pulse production the present investigation to generate more information to assess different row crop adjustments under a given set of management under rainfed condition.

II. RELATED WORK

A brief review of literature related to present investigation entitled, “Splash loss, water use efficiency, root development, seed equivalent yield and economics of pigeon pea based intercropping system under rainfed condition” was also carried out by various scientist in India and abroad. Especially on splash loss Pendke *et al.* (2004), on moisture studies, Prasad *et al.* (2003) and on economics, Kumar and Rana (2007) also reported similar findings, as reported by this two year experimentation.

III. MATERIALS AND METHODS

A field experiment was carried out at Soil Conservation and Water Management Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during 2015-16 and 2016-17. The soil of experimental field was sandy loam in texture with pH-7.6, Organic carbon-0.38%, Total N – 0.02%, available N – 172.1 kg ha⁻¹, available P₂O₅ -18.2 kg ha⁻¹, available K₂O – 182.2 kg ha⁻¹. The field capacity, wilting point and bulk density of the soil were 18.6%, 6.2% and 13.5 MgM³, respectively. The experiment was laid out in split plot design with three replication.

The treatments comprised 6 intercropping systems i.e. C₁- sole pigeon pea at 60cm by regular sowing, C₂- sole pigeon pea paired 40/80cm, C₃- Sole sorghum at 45cm by regular sowing, C₄- Sole urdbean at 45cm by regular sowing, C₅- Pigeon pea + sorghum paired sowing at 40/80cm, C₆- Pigeon pea + urdbean paired sowing at 40/80cm and 3 moisture conservation practices i.e. M₁- Control, M₂- Ridging and furrowing in between crop rows after three weeks of planting, M₃- Weeding and hoeing once at 35 days after sowing. The crop were sown on 22 July 2015 and 13 July 2016 during the first and second year of experimentation. The available soil moisture at sowing time upto 100cm soil profile was 280 and 290 mm, whereas the amount of rainfall occurred during the crop period was 237.1 and 401.0mm in 2015-16 and 2016-17, respectively against the average annual rainfall of Kanpur about 800mm.



Recommended package and practices and fertilizer given as indicated above were applied in different treatments. Soil moisture was determined by gravimetrically using the sample collected from 0-25, 25-50, 50-75 and 75-100cm soil depth at different crop growth stages. The amount of moisture used by the crop under different treatments were computed by summing up the value of soil moisture depletion from the soil profile during the entire crop period. Water use efficiency was calculated by the method as suggested by Viets (1962).

IV. RESULTS AND DISCUSSION

The data pertaining to splash loss presented in Table-1 indicated that different treatment caused marked variations for splash loss. The minimum values of splash loss 2.90 and 2.97 t/ha were estimated under urdbean regular (C_4 treatment) while highest values of splash loss i.e. 5.41 & 5.64 t/ha were recorded under pigeon pea (C_2 treatment) during experimentation. The values of splash loss regarding moisture conservation practices showed that the higher values 4.49 and 4.68 t/ha were noted under weeding & hoeing (M_3 treatment) during 2015-16 and 2016-17, respectively. As for as root depth is concerned highest root depth were measured in C_5 treatment, of cropping system while lowest values in this regards were measured in C_3 treatment of cropping system during both the year. The data referring to number of primary, secondary and tertiary root as well as fresh and dry weight (g) of root were measured in C_6 treatment of cropping system during experimentation as for as moisture conservation practices is concern the highest root development parameters i.e. root depth, number of primary, secondary & tertiary roots as well as fresh & dry weight of roots were measured in M_2 (Ridging & furrowing) treatment during 2015-16 and 2016-17, respectively, which is presented in Table-1.

As for as consumptive water use, water use efficiency & water taken per day by crop plant were measured and presented in Table-2 showed that highest consumptive use of water measured in treatments C_5 (Pigeon pea+ sorghum paired) while minimum in treatment C_4 (sole urdbean) of cropping system and in case of moisture conservation practices highest values of consumptive water use was estimated in control treatment during experimentation. The values in respect of per day water used by crop plant is presented in Table-2 reveal that minimum water used by pigeon pea + urdbean (C_6) treatment i.e. 1.86 mm/day given which highest value of water use efficiency i.e. 4.78 and 4.74 kg grain/mm of water during both the year, while minimum values in this regards computed C_3 - sole sorghum treatment i.e. 2.04 and 2.02 kg grain/ha/mm of water. As for as moisture conservation practices is concerned by using minimum amount of water per day i.e. 1.63 and 1.62mm ridge and furrowing gave highest water use efficiency evidently 4.08 and 4.05 kg grain/ha/mm of water during experimentation. As for as data pertaining to moisture extraction pattern is concerned maximum amount of moisture per cent (40.26 and 40.60%) extracted from the surface layer (0-25cm) by every cropping systems and moisture conservation practices, while minimum values of moisture extraction pattern i.e. 11.28 and 10.86 per cent extracted from deeper layer (75-100cm) during both the year of experimentation.

As for as seed equivalent yield (q/ha) and net return is concerned highest seed equivalent yield and net return were recorded in C_6 - Pigeon pea + Urdbean treatment under cropping system and minimum values of these parameters were recorded C_3 treatment, in case of moisture conservation practices highest values of these parameters recorded in M_2 treatment while lowest in M_1 - control treatment. These above presented results in accordance with those of Kumar *et al.* (2012), Srinivas *et al.* (2008), Upadhyay *et al.* (2010), Pendke *et al.* (2004) & Kumar & Rana (2007).

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Table-1: Effect of intercropping system and moisture conservation practices on pigeon pea equivalent yield (q/ha), splash loss (t/ha) and root development.

| Treatments | Pigeonpea equivalent seed yield (q/ha) | Splash Loss (t/ha) | Root depth (cm) | No. of tertiary roots/ plant | No. of primary root/ plant | No. of secondary root/ plant | Fresh root weight/ plant | Dry root weight/ plant |
|--|--|--------------------|-----------------|------------------------------|----------------------------|------------------------------|--------------------------|------------------------|
| | 2015-16 | 2015-16 | 2015-16 | 2015-16 | 2015-16 | 2015-16 | 2015-16 | 2015-16 |
| Cropping system | | | | | | | | |
| C ₁ - Sole pigeonpea regular | 14.79 | 5.20 | 73.5 | 20.2 | 28.4 | 51.7 | 60.2 | 29.9 |
| C ₂ - Sole pigeonpea paired | 17.36 | 5.41 | 77.8 | 18.6 | 26.6 | 48.6 | 56.5 | 28.1 |
| C ₃ -Sole sorghum regular | 19.13 | 4.80 | 21.8 | - | 29.7 | - | 11.6 | 6.6 |
| C ₄ - Sole urdbean regular | 8.74 | 2.90 | 22.4 | 11.0 | 12.6 | 24.2 | 3.9 | 2.3 |
| C ₅ -Pigeonpea+Sorghum paired | 18.94 | 3.92 | 24.7 | 16.5 | 24.5 | 42.4 | 51.5 | 25.7 |
| C ₆ -Pigeonpea+urdbean paired | 22.78 | 3.35 | 25.6 | 17.3 | 25.7 | 44.9 | 53.6 | 26.7 |
| SE+ (d) | 0.76 | - | - | - | - | - | - | - |
| CD at 5% | 1.70 | - | - | - | - | - | - | - |
| Moisture conservation practices | | | | | | | | |
| M ₁ -Control | 12.76 | 4.0 | 90.5 | 16.3 | 22.0 | 42.2 | 49.3 | 24.6 |
| M ₂ -Ridging and furrowing | 17.58 | 4.33 | 73.7 | 20.5 | 30.2 | 52.0 | 60.9 | 30.3 |
| M ₃ -Weeding and hoeing | 14.24 | 4.49 | 81.2 | 18.5 | 26.7 | 46.5 | 56.0 | 27.9 |
| SE+ (d) | 0.59 | - | - | - | - | - | - | - |
| CD at 5% | 1.21 | - | - | - | - | - | - | - |
| | 2016-17 | 2016-17 | 2016-17 | 2016-17 | 2016-17 | 2016-17 | 2016-17 | 2016-17 |
| Cropping system | | | | | | | | |
| C ₁ - Sole pigeonpea regular | 15.83 | 5.38 | 70.7 | 22.5 | 31.0 | 52.8 | 62.5 | 30.1 |
| C ₂ - Sole pigeonpea paired | 18.66 | 5.64 | 73.9 | 21.2 | 29.4 | 50.1 | 59.9 | 28.8 |
| C ₃ -Sole sorghum regular | 20.95 | 4.99 | 19.7 | - | 31.5 | - | 13.1 | 7.5 |
| C ₄ - Sole urdbean regular | 9.88 | 2.97 | 21.0 | 12.8 | 14.6 | 25.7 | 4.6 | 2.7 |
| C ₅ -Pigeonpea+Sorghum paired | 22.12 | 4.12 | 85.6 | 18.4 | 26.9 | 46.0 | 55.4 | 26.7 |
| C ₆ -Pigeonpea+urdbean paired | 23.69 | 3.59 | 79.1 | 20.1 | 28.3 | 47.5 | 57.4 | 27.6 |
| SE+ (d) | 0.38 | - | - | - | - | - | - | - |
| CD at 5% | 0.85 | - | - | - | - | - | - | - |
| Moisture conservation practices | | | | | | | | |
| M ₁ -Control | 13.69 | 4.19 | 84.9 | 17.4 | 25.6 | 45.2 | 53.1 | 25.6 |
| M ₂ -Ridging and furrowing | 18.26 | 4.48 | 70.2 | 23.3 | 31.9 | 53.2 | 63.6 | 30.6 |
| M ₃ -Weeding and hoeing | 15.51 | 4.68 | 76.8 | 21.7 | 29.2 | 48.9 | 59.7 | 28.7 |
| SE+ (d) | 0.53 | - | - | - | - | - | - | - |
| CD at 5% | 1.10 | - | - | - | - | - | - | - |



Table-2: Effect of intercropping system and moisture conservation practices on total water use, water use efficiency, water used by crops/day and moisture extraction & economics.

| Treatments | Moisture extraction pattern | | | | Total water use (mm) | Water use efficiency (kg grain/ha) | Water use by crop plant/day (mm) | Net return (Rs/ha) |
|--|-----------------------------|---------|---------|---------|----------------------|------------------------------------|----------------------------------|--------------------|
| | 0-25 | 25-50 | 50-75 | 75-100 | | | | |
| | 2015-16 | 2015-16 | 2015-16 | 2015-16 | 2015-16 | 2015-16 | 2015-16 | 2015-16 |
| Cropping system | | | | | | | | |
| C ₁ -Sole pigeonpea regular | 38.04 | 28.62 | 21.34 | 12.0 | 468.1 | 3.16 | 1.87 | 48202 |
| C ₂ -Sole pigeonpea paired | 37.40 | 28.51 | 21.46 | 12.33 | 473.5 | 3.67 | 1.88 | 61460 |
| C ₃ -Sole sorghum regular | 45.10 | 28.32 | 17.15 | 9.43 | 319.1 | 2.04 | 2.55 | 11148 |
| C ₄ -Sole urdbean regular | 45.94 | 28.52 | 16.58 | 8.96 | 295.4 | 2.96 | 2.95 | 17532 |
| C ₅ -Pigeonpea+Sorghum paired | 37.36 | 28.58 | 21.56 | 12.50 | 481.5 | 3.95 | 1.89 | 66006 |
| C ₆ -Pigeonpea+urdbean paired | 27.42 | 28.62 | 21.50 | 12.46 | 477.8 | 4.78 | 1.86 | 83027 |
| SE+ (d) | - | - | - | - | - | - | - | - |
| CD at 5% | - | - | - | - | - | - | - | - |
| Moisture conservation practices | | | | | | | | |
| M ₁ -Control | 40.05 | 28.26 | 20.07 | 11.62 | 423.4 | 2.92 | 1.69 | 40610 |
| M ₂ -Ridging and furrowing | 40.47 | 28.81 | 198.44 | 11.28 | 414.6 | 4.08 | 1.63 | 59473 |
| M ₃ -Weeding and hoeing | 40.26 | 28.52 | 20.28 | 10.94 | 419.6 | 3.28 | 1.65 | 43604 |
| SE+ (d) | - | - | - | - | - | - | - | - |
| CD at 5% | - | - | - | - | - | - | - | - |
| | 2016-17 | 2016-17 | 2016-17 | 2016-17 | 2016-17 | 2016-17 | 2016-17 | 2016-17 |
| Cropping system | | | | | | | | |
| C ₁ -Sole pigeonpea regular | 38.46 | 28.94 | 21.06 | 11.54 | 488.3 | 3.24 | 1.87 | 53774 |
| C ₂ -Sole pigeonpea paired | 38.22 | 28.70 | 21.25 | 11.78 | 492.8 | 3.79 | 1.88 | 69626 |
| C ₃ -Sole sorghum regular | 45.38 | 28.58 | 17.08 | 8.96 | 338.6 | 2.02 | 2.60 | 10080 |
| C ₄ -Sole urdbean regular | 46.15 | 28.77 | 16.52 | 8.56 | 314.2 | 3.12 | 3.20 | 22520 |
| C ₅ -Pigeonpea+Sorghum paired | 37.59 | 28.76 | 21.41 | 12.24 | 502.4 | 4.01 | 1.89 | 75763 |
| C ₆ -Pigeonpea+urdbean paired | 37.80 | 28.93 | 21.19 | 12.08 | 499.5 | 4.74 | 1.86 | 92439 |
| SE+ (d) | - | - | - | - | - | - | - | - |
| CD at 5% | - | - | - | - | - | - | - | - |
| Moisture conservation practices | | | | | | | | |
| M ₁ -Control | 40.28 | 28.51 | 20.02 | 11.19 | 441.1 | 2.99 | 1.70 | 46641 |
| M ₂ -Ridging and furrowing | 40.91 | 28.96 | 19.52 | 10.61 | 435.0 | 4.05 | 1.62 | 64893 |
| M ₃ -Weeding and hoeing | 40.64 | 28.87 | 19.71 | 10.78 | 438.8 | 3.42 | 1.65 | 50568 |
| SE+ (d) | - | - | - | - | - | - | - | - |
| CD at 5% | - | - | - | - | - | - | - | - |



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