Productivity, Water Use Efficiency and Economics of Rainfed Niger (*Guizotia abyssinica*) as Influenced by Mulching and Row Spacing in Red and Lateritic Soil of West Bengal, India

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Abstract

A field experiment was conducted in the red and lateritic loamy sand soil of Birbhum, West Bengal, India during winter season of 2004-05 and 2005-06 to assess the response of rainfed niger [*Guizotia abyssinica* (L.f.) Cass.] to mulching and row spacing. The results revealed that black polythene mulched plots gave on an average 530 kg ha^{-1} seed yield that was 5.1, 12.8 and 16.4% higher as compared to rice straw, soil dust and no mulching plots, respectively. Row spacing of 30 cm showed better performance and recorded 6.2% and 11.3% in 2004-05 and 7.1% and 14.6% in 2005-06 higher seed yield as compared to 25 cm and 20 cm row spacing, respectively. Water use efficiency was highest under black polythene mulched treatment and niger crop grown at a row spacing of 30 cm. Highest net return and B:C ratio was recorded under control treatment and niger crop grown at 30 cm row spacing.

1. Introduction

It is well known that climate specifically the rainfall is the greatest controlling factor in agriculture. Nearly 76% area under oilseed crop is rainfed, which is often subjected to vagaries of monsoon (Hegde, 2006). In such areas oilseed production is mainly depended upon intensity and frequency of rainfall, which directly governs the soil moisture regime. It is reported in several literatures that soil moisture content is the most limiting factor for crop production (Reddy and Reddi, 2002). A great portion of soil moisture in rainfed situation is lost through evaporation process from the soil surface and through transpiration process from the plant canopy. Niger [*Guizotia abyssinica* (L.f.) Cass.], a minor oilseed crop, contributes to about 0.5% of Indian's oilseed production. In West Bengal, it is cultivated over an areas of 0.08 million ha with a production of 0.05 million tonnes grown in marginal and sub-marginal lands, mainly in tribal pockets purely under rainfed condition. In order to increase the production and productivity of niger under rainfed condition, mulching technology may be adopted. Mulching checks the loss of soil moisture through evaporation process, suppresses weed growth and provides favourable soil moisture regime for plant growth (Kumar et al., 2006). Optimum row spacing and plant population are important factors determining the productivity of oilseed crops under rainfed condition. Research efforts on the effect of various types of mulches and row spacing on performance of rainfed niger in red and lateritic zone of West Bengal is scanty. Therefoe, the main focus of this study is to assess the response of rainfed niger [*Guizotia abyssinica* (L.f.) Cass.] to various types of mulching and row spacing.

2. Materials and Methods

Field investigation was carried out at the agriculture farm ($23^0$39' N, $87^0$42' E with an elevation of 58.9 m above msl), of Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal, India during winter (*rabi*) season of 2004-05 and 2005-06. The soil in the experimental field was lateritic loamy sand in texture having pH 6.2. It was low in organic carbon (0.48%), available nitrogen (249.6 kg N ha^{-1}) and medium in available phosphorus (17.0 kg P ha^{-1}) and available potassium (125.8 kg K ha^{-1}). The experiment was laid out in split-plot design with 3 replications. The study consisted of combinations of four mulching treatments: no mulching, soil dust mulching, rice straw mulching @ 5 t ha^{-1} and black polythene (0.05 mm thick). These mulching treatments were laid out as the main plots. Treatments on three row spacing (20, 25 and 30 cm) were laid out as the sub-plots. 'Birsa Niger-1' was sown as per treatment on 9th November and 14th November and harvested

on 11th February and 18th February during 2004-05 and 2005-06, respectively. Recommended fertilizer dose of 40-20-20 kg ha^{-1} of N-P_2O_5-K_2O was applied as basal dose through urea, single super phosphate and muriate of potash during final land preparation. Mulches were applied after plant emergence at 15 days after sowing (DAS). Black polythene sheets of 4 × 3 m^2 plot size measurement were cut parallely according to the row spacing of the crop and spread over the plot. Soil dust mulching in between crop rows was done with the help of hand hoe twice at 15 and 40 DAS. The other cultural operations were carried out as per recommendations in this region. Soil samples from 0-15, 15-30 and 30-60 cm layers were collected with the help of screw auger from net plot area of each treatment and were kept in aluminum soil moisture boxes and soil moisture contents from 0-15, 15-30 and 30-60 cm profile depth were estimated thermo gravimetrically. Consumptive use (CU) of water by the crop in each plot was determined from the soil moisture content and bulk density of the soil at respective depth using the water depletion method by the following formula.

$$U = \sum_{i=1}^{n} \frac{(\theta_{1i}-\theta_{2i})}{100} \times p_{bi} \times d_i + ER$$

$$CU = \sum_{i=1}^{m} U$$

where, U = Consumptive use (cm) during a given period, CU = Total seasonal consumptive use (cm), θ_{1i} = soil moisture content of initial soil sample or just after rainfall in i^{th} soil layer (%, w/w), θ_{2i} = soil moisture content of successive soil sample or at harvest in i^{th} soil layer (%, w/w), ρ_{bi} = bulk density of the i^{th} soil layer (g cc^{-1}), d_i = depth of i^{th} soil layer, n = number of soil layers in the root zone (0-15, 15-30 and 30-60 cm), m = number of periodical observations on soil samples, ER = effective rainfall during crop growth period (cm). Water use efficiency (WUE) was calculated as ratio of seed yield to CU. Total amount of rainfall during the crop season of 2004-05 and 2005-06 was 62.3 and 9.0 mm, respectively.

3. Results and Discussion

3.1. Mulching

Data on yield and plant height during both the year are presented in Table 1. It was found that plant height and yield attributes were significantly influenced by mulching treatments during both the year. Plant height, capitula $plant^{-1}$ and seeds $capitula^{-1}$ was significantly higher with black polythene mulch than other mulch treatments. However, seeds $capitula^{-1}$ during 2004-05 under black polythene mulch was at par with that obtained with rice straw mulch. Soil dust mulching did not result any significant improvement in these parameters over control. Mulching helps to conserve soil moisture through reduced evaporation; besides its role to regulate soil temperature and to control weeds and thus helps in efficient use of residual soil moisture. Adequate availability of moisture to plants resulted in better cell turgidity and eventually higher meristematic activity, leading to more foliage development, greater photosynthetic rate, better plant growth and consequently favourable effect on sink components and was also reported by Mandal et al. (1991) and Yadav et al. (2006). Seed and biological yield also followed the similar trend as observed for yield attributes during both the years (Table 2) and were significantly higher under polythene mulch. Soil dust mulching had no added advantage over unmulched system. Due to better plant growth and physiological activities, mulching with polythene sheet increased seed and biological yield significantly. On an average 5.1, 12.8 and 16.4% increase in seed yield were recorded in polythene mulched plot compared to rice straw, soil dust and control plots, respectively. The results are in agreement with findings of Yadav et al. (2006). They reported that black polythene mulch significantly increased yield attributes, seed, stover and biological yield of *Brassica juncea* (L.) Czem and Cosson over *Saccharum munjo* (@ 5 t ha^{-1}), *Tephrosia purpurea* (@ 5 t ha^{-1}) and no mulching. Water use efficiency (WUE) and consumptive use of water (CUW) by the crop were also significantly influenced by mulching treatment in both the years (Table 2). The CUW by niger crop (0-60 cm soil layer) was found maximum under control, however, WUE was highest under polythene mulched treatment probably due to reduced evaporation loss and increased seed yield, which was consistent with the observations of Chaudhary et al. (2003) and Saren et al. (2008). Black polythene mulching improved the plant height as well as branches $plant^{-1}$ which resulted in increased biological yield and seed yield of rainfed niger. The cost of cultivation was found highest under black polythene mulching whereas it was lowest under control treatment during both the years (Table 3). Black polythene mulching although gave highest net return during 2005-06 but the highest B:C ratio was recorded in control treatment owing to lower cost of cultivation during both the year of experiment.

3.2. Row spacing

Row spacing also influenced plant height, yield attributes and yield during both the years (Table 1 and 2). The plant height and yield attributes, viz. branches $plant^{-1}$, capitula $plant^{-1}$, seeds $capitula^{-1}$ were significantly higher in 30 cm row spacing (4.76 lakh plants ha^{-1}) as compared to 25 cm (5.72 lakh plants ha^{-1}) and 20 cm (7.14 lakh plants ha^{-1}) row spacing. The favourable effect of 30 cm row spacing on sink components could be attributed to better development of the plants in terms of plant height and dry weight at initial growth stages on account of favourable temperature, enabling the $plants^{-1}$ to produce optimum leaf area which, in turn, gave more capitula $plant^{-1}$and seeds $capitula^{-1}$ with relatively bolder seeds in comparison to

Table 1: Effect of mulching and row spacing on plant height, yield attributes of rainfed niger

Treatment	Plant height (cm)		Branches plant^{-1}		Capitula plant^{-1}		Seeds capitula^{-1}		1,000 seed weight (g)	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Mulching										
Control	67.19	60.42	10.05	9.06	24.89	21.60	37.84	35.67	5.45	5.30
Soil dust	70.90	61.71	9.50	9.96	26.33	23.85	39.53	37.88	5.18	5.28
Rice straw	76.11	67.47	12.11	11.02	28.66	25.98	40.77	38.56	5.44	5.35
Black polythene	87.30	72.60	12.77	11.68	34.36	30.91	42.49	39.99	5.60	5.40
SEm±	1.67	1.06	0.41	0.32	0.92	0.56	0.52	0.43	0.17	0.11
CD (p<0.05)	4.58	2.91	1.00	0.77	2.24	1.38	2.58	1.06	NS	NS
Row spacing (cm)										
20	74.02	61.50	10.04	9.71	27.06	24.60	38.24	36.39	5.28	5.30
25	75.20	64.17	10.83	10.12	28.48	25.21	38.71	36.68	5.40	5.34
30	76.90	71.02	12.46	11.45	30.13	26.94	43.52	41.00	5.57	5.36
SEm±	0.44	1.13	0.42	0.25	0.41	0.54	0.45	0.37	0.13	0.07
CD (p<0.05)	1.09	2.79	0.88	0.53	1.01	1.15	1.11	0.78	NS	NS

NS=Not significant

Table 2: Effect of mulching and row spacing on yields, harvest index, consumptive use and water use efficiency of rainfed niger

Treatment	Seed yield (kg ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)#	Consumptive use (cm)		Water use efficiency (kg ha-cm^{-1})	
	2004-05	2005-06	2004-05	2005-06		2004-05	2005-06	2004-05	2005-06
Mulching									
Control	472	440	2.83	2.75	16.35	17.42	16.07	27.07	27.38
Soil dust	484	457	2.85	2.82	16.60	17.00	15.65	28.48	29.20
Rice straw	518	492	3.03	3.04	16.65	16.87	15.52	30.72	31.66
Black polythene	541	520	3.20	3.11	16.80	16.75	15.40	32.27	33.71
SEm±	10	10	0.12	0.13	0.27	0.21	0.20	0.80	0.74
CD (p<0.05)	25	24	0.32	0.35	NS	0.57	0.55	2.19	2.03
Row spacing (cm)									
20	478	445	2.85	2.78	16.40	16.61	15.26	28.77	29.20
25	501	476	2.96	2.94	16.55	17.05	15.70	29.39	30.35
30	532	510	3.11	3.11	16.75	17.37	16.02	30.63	31.92
SEm±	10	10	0.08	0.09	0.24	0.19	0.19	0.43	0.50
CD (p<0.05)	21	21	0.19	0.24	NS	0.47	0.47	1.06	1.24

#Mean of two years, NS=Not significant

25 cm and 20 cm row spacing. The results were in conformity with Yadav et al. (2006). The highest seed yield, biological yield and harvest index of niger were recorded in 30 cm row spacing while the lowest were recorded in 20 cm row spacing during both the year of experiment. Row spacing of 30 cm recorded 6.2% and 11.3% in 2004-05 and 7.1% and 14.6% in 2005-06 higher seed yield as compared to 25 cm and 20 cm row spacing, respectively. The wider row spacing might have promoted production of more effective branches plant^{-1}, more capitula plant^{-1} and increased number of seeds capitula^{-1} which resulted in higher yield. Similar observations were reported by Rafey (2004) in niger. In both the year water use efficiency and consumptive use of water by the crop were also significantly influenced by row spacing (Table 2). Row spacing of 30 cm

Table 3: Effect of mulching and row spacing on economics of rainfed niger cultivation

Treatment	Cost of cultivation (₹ ha^{-1})		Gross Return (₹ ha^{-1})		Net Return ₹ ha^{-1})		Benefit:Cost ratio	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Mulching								
Control	4828	4928	8263	7699	3435	2771	0.71	0.56
Soil dust	5528	5695	8472	8003	2944	2308	0.53	0.41
Rice straw	6108	6308	9070	8621	2962	2313	0.48	0.37
Black polythene	6158	6318	9482	9121	3324	2803	0.54	0.44
Row spacing (cm)								
20	5861	6004	8379	7806	2518	1802	0.43	0.30
25	5656	5841	8773	8340	3117	2499	0.55	0.43
30	5461	5588	9306	8924	3845	3336	0.70	0.60

Price of niger seed ₹ 17.00 kg^{-1} and Stover ₹ 0.15 kg^{-1}

recorded maximum consumptive use and water use efficiency during both the years. The lower water use efficiency was recorded under 20 cm row spacing which was attributed to lower seed yield in the treatment. Similar results were also reported by Momoh et al. (2004) and Saren et al. (2008). Row spacing of 30 cm recorded highest net return and also B:C ratios whereas lowest net return as well as B:C ratio was recorded at 20 cm row spacing during both the years (Table 3). This was due to higher returns obtained and relatively lower cost of cultivation in 30 cm row spacing.

4. Conclusion

From the two year investigation it is concluded that sowing at 30 cm row spacing and use of black polythene or rice straw as mulch resulted in higher growth, productivity and water use efficiency of rainfed niger. But mulching treatments are not economically promising for productivity and profitability of this crop grown under red and lateritic soil of West Bengal.

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