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Effect of seeding density on suppression of weeds and performance of wheat (*Triticum aestivum*)

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Wheat (*Triticum aestivum* L emend. Fiori & Paol) is one of the most important food crop in the world, providing 20% of humanity's dietary energy supply and serving as the main source of protein in developing nations (Braun *et al*. 2010). Wheat is an important staple food crop, plays an important role in food security of the country. It occupied 28.82 million ha area with a total production of 93.0 million tonnes and the national average productivity of 2.9 tonnes/ha (Economic Survey 2012). During the post green revolution, the productivity of wheat has increased tremendously but is still far below the potential yield, i e 11.2 tonnes/ha (Singh *et al.* 2010). Moreover, productivity of wheat is not uniformly distributed all over the country due to several biotic and abiotic constraints which limits the productivity of wheat at farmer's level. Of the several constraints to low productivity of wheat, indiscriminate use of high seeding density has been recognized as an important one in the central part of the country. Southern Rajasthan and adjoining Malwa plateau region require higher seeding density due to prevalence of high temperature during tillering stage and shorter winter season. In wheat variable seeding densities used in different parts of India ranges from 50 to 150 kg/ha depending on varying seed size, time and method of sowing. In general, a higher seeding density is required to secure an optimum and effective plant population for better yield and it is also expected to reduce weed growth. In fact, studies showed that weed population suppressed substantially through increasing plant population (Olsen *et al*. 2006). It has also been noted that the increase of seeding density and early sowing time is unfavorable, but the negative effect of late sowing could be compensated by the increase of seeding density. Keeping above facts in view, the present study was carried out on the farmer's field to assess the impact of seeding density on weeds and its performance on wheat.

The field experiment was conducted during two consecutive winter season of 2010-11 and 2011-12 at farmer's field of Banswara district of southern Rajasthan. Before conducting on farm trials (OFT), Participatory Rural Appraisal (PRA) was done to identify reasons of poor yield of wheat and high cost of production. Heavy seeding density over 200 kg/ha was identified as a serious constraint in southern tribal dominated Rajasthan and central region of the country. Therefore, replicated on farm trials were conducted at five farmer's field in Gamri villge of Banswara district of Rajasthan and means were used for the study. The location was in the valley region in mid hill conditions of Malwa Plateau at an elevation of around 225 m above mean sea level and characterized on the basis of long term by semi-arid and subtropical type of climate. All the farmers selected for on farm trials were small. The soil of the sites was light black loam in texture, pH 7.5 and low in available organic carbon (0.35%) and available N (213.5 kg/ha), medium in available P (13.6 kg/ha) and K (258 kg/ha). The crop experienced the average minimum temperature 9.2^{o}C and 7.7^{o}C in January while average maximum temperature 37.2^{o}C and 35.8^{o}C in March during both the years of experimentation. The experiment comprised of four treatments of seeding density, viz. 125, 150, 175 kg/ha and farmers practice of 200 kg/ha were laid out in a randomized block design at each farmer's field. Wheat variety Raj 4037 was sown during last week of November (28-30 November) during both the years. The crop was fertilized with recommended doses of 100-50-50 kg N-P-K/ha of this region. No weeding was performed during entire crop growth period. Data on weed density were recorded at 90 days after sowing in each plot in two quadrants of 1 m × 1 m. Crop was manually harvested on last week of March (25-30 March) in each year. The yield attributes were recorded before harvest of crop. The grain yield data were recorded and adjusted to 14% of the moisture content. For estimation of energy inputs and outputs, energy equivalents were worked out as suggested by Devasenapathy *et al*. (2009) and Salami and Ahmadi (2010). Data were analyzed statistically to draw a valid conclusion. The general cost of production of wheat was estimated ₹ 23 033/ha. Treatment wise economics was computed using the prevailing market

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Table 1 Effect of seeding density on weeds, growth, yield attributes and yield of wheat (mean data of two years)

Seed rate	Weed density/ (m^2)	Plant height (cm)	Spikes/m row length	Spike length (cm)	Seeds/ Spike	1000 seed weight (g)	Biological yield (tonnes/ha)	Straw yield (tonnes/ha)	Grain yield (tonnes/ha)
Recommended (125 kg/ha)	12.80	82.93	112.25	8.48	42.35	43.00	12.50	7.64	4.64
Refined (150 kg/ha)	9.80	82.71	117.40	8.53	43.50	43.30	12.97	8.02	5.15
Refined (175 kg/ha)	7.70	82.20	115.20	8.28	42.20	42.00	12.58	8.11	5.05
Farmer's practice (200 kg/ha)	8.20	81.79	114.80	7.80	39.46	41.96	11.12	7.27	3.85
CD (P = 0.05)	2.31	NS	4.57	0.35	1.67	NS	0.87	0.66	0.44

Table 2 Effect of seeding density on economics, sustainability and energetics of wheat (mean data of two years)

Seed rate (kg/ha)	SYI	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C	Energy input (MJ/ha)	Energy output (MJ/ha)	Energy use efficiency	Net energy return (MJ/ha)	Energy productivity (kg/MJ)
Recommended (125 kg/ha)	0.68	23533	62392	38859	2.65	14967	188614	12.6	173647	0.31
Refined (150 kg/ha)	0.72	24033	67610	43577	2.81	15334	200630	13.1	185296	0.33
Refined (175 kg/ha)	0.68	24533	67526	42993	2.75	15702	203078	12.9	187376	0.32
Farmer's practice (200 kg/ha)	0.46	25033	52700	27667	2.10	16069	171170	10.7	155101	0.24

price of seed (₹ 20/kg) and labour wages ₹ 150/man day and out puts, viz. wheat grain ₹ 11.80/kg and straw ₹ 1/kg.

The major weed flora observed in the experimental sites comprised broad leaf weeds, viz. *Chenopodium album (40%), Melilotus indica (7.5%), Anagallis arvensis (5%),* and *Convolvulus arvensis (5%)*, and among grassy weeds, viz. *Phalaris minor (17.8%), Cynodon dactylon (3%), Poa annua (8.5%)* and *Avena fatua (5%)*. Weed population was significantly suppressed in crop sown at higher seeding density of 150, 175 and 200 kg/ha as compared to seeding density of 125 kg/ha. Increased plant density caused smothering effect on weeds and consequently reduced dry matter accumulation of weeds. Results are corroborated with the research findings of Sharma and Singh (2011).

Effect of seeding density on plant height and 1 000 seed weight was found non-significant (Table 1). The numbers of spikes/meter row length, spike length, grains/spike, straw yield, grain yield and biological yield significantly increased under 150 kg/ha but further increased in seeding density resulted reduction in these parameters. More number of grains per spike and higher spike length at lower seeding density was due to less competition among the plants for light, moisture and nutrients compared with those of higher seeding densities. The mutual competition among plants at higher seeding density decreased the grains per spike and 1 000 seed weight (Sharma and Singh 2011). Variation in seeding densities significantly influenced the grain and straw yield of wheat also reported by Pyare *et al*. (2012).

The maximum net returns (₹ 43 577) and B:C ratio (2.81) was recorded under 150 kg seed/ha. Further increase in seeding density from 150 kg/ha to 175 kg/ha gave slight reduction in net return and B:C ratio but at farmer's practice caused drastic reduction in net return (₹ 27 667) and B:C ratio (2.10) owing to higher cost of seed and lower yield (Table 2). Pyare *et al*. (2012) also recorded higher net return and B:C ratio with 150 kg/ha seeding density of wheat.

The highest energy output, energy use efficiency (EUE), net energy return, energy productivity and sustainability were recorded with 150 kg/ha seeding density of wheat while lowest with farmer's practice (Table 2). It might be due to higher energy requirement under farmer's practice using heavy seeding density and lower productivity. Energy output has direct relation with total biomass production and was highest with 150 kg/ha seeding density of wheat.

SUMMARY

An on-farm trial was conducted at five farmer's field of Banswara district of Rajasthan to validate, refine and popularize the technology developed by Maharana Pratap University of Agriculture and Technology, Udaipur for managing weed flora in wheat (*Triticum aestivum* L emend. Fiori & Paol) during 2010-11 to 2011-12. Results showed that the seeding density has positive correlation on suppression of weed population. Seeding density over 150 kg/ha significantly suppressed the weed floras. Due to lower weed population and higher yield contributing components under 150 kg/ha seeding density gave 20.8%, 1.4% and 33% more grain yield over 125 and 175 kg/ha and farmer's practice respectively. The highest net return, B:C ratio, energy output, energy use efficiency, energy productivity and sustainability yield index (SYI) were also recorded

with 150 kg/ha seeding density. It can be recommended that 150 kg/ha seeding density of wheat is sufficient to get maximum return in southern Rajasthan and Central Malwa Plateau region. With this intervention tribal farmers of the southern Rajasthan can reduce their cost of production and save energy as well.

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