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Low seed rate at surface sowing enhance resilience of physiological parameters and economics of wheat (*Triticum aestivum*)

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Wheat (*Triticum aestivum* L.) occupies a prominent place as an important staple crop contributing 40% in the total foodgrain production and is next only to rice. It is grown in 27.75 million hectare in India with the production of 80.68 million tonnes and with 2 907 kg/ha productivity (DES 2008). Sustaining the crop productivity is a challenge as it is influenced by several factors. The best agronomic practices for exploiting the yield potential of particular cultivar mainly depend on sowing method and seed rate which directly influence growth and yield. Maintaining more population per m^2 area and leaving narrow gaps between rows are in practice including in India, but exact seed rate and sowing depth are important factors as they have impacts on seeding emergence, vigour and consequently on yield. Studies recommended varying levels of seed rates such as 125 kg/ha (Singh and Uttam 1994), 150 kg/ha (Nazir *et al*. 2000) and 160 kg/ha (Ram *et al*. 1988). These results signify the spatial variation in optimal seed rates for better crop productivity. Seeds sown deeper than 4 cm decreased seedling emergence and ultimately yield. Seedling emergence reduced to a greater extent (82%) when sown at 8 cm depth (Rebetzia *et al.* 2007). Therefore objectives of our study were to assess in Kymore Plateau and Satpura Hills agro-climatic zone of Madhya Pradesh, effects of low, medium and high seeding rate and interaction with surface, medium and deep sowing on growth, yield and economics of wheat.

The field experiment was conducted during *rabi* season of 2009-10 for evaluating the effect of seed rates and sowing depths on growth, physiological parameters and economics of wheat at Research Farm of Adharatal, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh. Wheat (var GW 273) seeds were sown on 4th of December in sandy clay loam soil having 236.8 kg/ha alkaline permanganate oxidizable N, 20.10 kg/ha available P, 272.3 kg/ha K and 0.62% organic carbon with 7.3 pH. Fertilizers were applied @ 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. There were twelve treatment combinations includes four seed rates 40 kg/ha(S_1), 60 kg/ha(S_2), 80 kg/ha(S_3) and 100 kg/ha(S_4)) and three sowing depths 2 cm(D_1), 4 cm(D_2) and 6 cm(D_3) in factorial randomized block design with three replications at 20 cm row spacing. All the plots were irrigated uniformly. At regular intervals of 30, 60, 90 days after sowing (DAS) plant population per square meter was counted. During these intervals fresh and dry weight of fixed number of wheat plants were taken and represented on per square meter basis. Based on dry matter production during these intervals CGR and RGR were calculated. Crop was harvested at 130 DAS and yield and biomass were quantified. Economics of the whole experiment was worked out based on cost of cultivation and income. The benefit cost ratio was calculated as ratio of gross income to cost of cultivation.

Effect of seed rates

Plant height increased gradually up to 90 DAS; however the increment was rapid between 30 to 90 DAS under all the treatments. Plants were taller @ 80 kg/ha seed rate and are at par with 100 kg/ha while significantly superior over lower seed rates of 60 kg/ha and 40 kg/ha. Similar responses were seen in dry matter production, CGR and RGR (Table 1) suggesting enhanced growth at this seed rate leading to higher grain yield. The production of grain among treatments was in the order of S3 (60 q/ha)> S4 (53 q/ha)> S2 (48 q/ha)> S1 (45 q/ha). Results thus indicate inspite of lesser plant population plants could not capitalize on more availability of nutrient per plant in S_1 and S_2 treatments. This might be due

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Table 1 Influence of different seeding rates, viz. 40 kg/ha (S_1) 60 kg/ha (S_2) 80 kg/ha (S_3) 100 kg/ha (S_4) and sowing depths, viz. 2 cm (D_1) 4 cm (D_2) 6 cm (D_3) on plant height, dry matter production, CGR (g/m^2/day), RGR (g/g/day) and yield in wheat grown during 2009-10

Treatment	Plant height (cm)			Dry matter production/m^2		Physiological parameters		Yield (q/ha)	
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	CGR (60 DAS)	RGR (60 DAS)	Seed	Straw
Seed rates									
40 kg/ha (S_1)	29.47	65.58	81.92	245.91	636.76	9.86	0.01845	45.48	83.91
60 kg/ha (S_2)	30.8	66.22	82.01	249.40	659.09	11.66	0.01779	48.51	85.88
80 kg/ha (S_3)	31.56	67.83	83.84	266.67	687.56	12.80	0.01773	60.69	95.00
100 kg/ha (S_4)	31.50	66.22	82.61	255.94	664.93	12.17	0.01834	53.90	90.82
SEm±	0.42	0.094	0.54	3.82	8.08	0.34	0.00031	4.26	2.42
CD (P = 0.05)	1.43	3.19	1.84	10.83	23.01	1.20	0.00106	12.39	6.72
Sowing depths									
2 cm (D_1)	31.58	67.38	83.27	263.95	685.29	12.42	0.01789	55.52	92.39
4 cm (D_2)	30.67	66.65	82.90	253.89	657.66	11.64	0.01739	52.29	88.94
6 cm (D_3)	29.71	65.21	81.62	245.60	643.30	11.38	0.01839	48.63	85.38
SEm±	0.49	1.09	0.63	3.59	9.86	0.39	0.00036	1.47	1.27
CD (P = 0.05)	2.48	2.77	1.59	10.20	27.63	1.00	0.00183	3.93	3.22

to more exposure of soil leading to higher evaporation and dryness. Yield declined in S_4 as compared to S_3 plots can be attributed to internal competition of plants to the available moisture and nutrients. Several studies investigated the influence of seeding rates on wheat yield however a consensus was not observed and have recommended different seeding rates for prosperous growth and better yield (Soomro *et al.* 2009, Sen *et al.* 2003, Kaur *et al.* 2002).

Effect of sowing depths

Results indicate reduction in plant height with deeper sowing indicating the influence seeding emergence and overall vigour. However variation was only slight (Table 1). This might be due to biomass quantified at regular interval revealed the influence of deeper sowing on the growth and physiology. It was lowest in deep sowing and found increases with surface sowing. Response was similar at all measured intervals. A significant decrease in CGR was apparent in wheat with deeper sowing with least CGR in D_3 as compared to other two treatments. These indicate the slower growth and declined crop vigour in case of deeper sowing. Results revealed no significant effect of sowing depth on RGR. Response was not consistent among different sowing depths however it was lowest (0.01739 g/g/day/m^2) in D_2 as compared to D_1 and D_3. Influence of sowing depth on growth rate and biomass production is reported elsewhere (Rebetzia *et al* 2007). Effects of different sowing depths on crop growth and physiological characteristics like CGR have direct influences on grain production. Grain yield was highest in D_1 (55 q/ha) and least in D_3 (48 q/ha) with intermediate responses in D_2 (52 q/ha). Similar responses were observed in straw yield as well (Table 1). Early seedling emergence with longer coleoptiles reported to have positive correlation with grain yield (Yagmur *et al*. 2009). In this study we found a significant positive relation (r^2=0.902) between CGR and grain yield under different sowing depths (Fig 1B).

Interaction between seeding rates and sowing depths

Interaction between plant height, dry matter production, CGR and RGR were non-significant but in case of grain and straw yields it was significant.

Effect of different seed rates and sowing depths on economics

The cost of cultivation per hectare of the crop increased with increases in seeding rate due to additional cost for procuring seeds. Total cost was maximum in S_4 treatment @ 21 215 ₹/ha while investment was minimum in S_1 (₹ 19 415/ ha) There was no additional cost incurred due to different depth of sowing (Table 2). The net monetary return (NMR) is the actual profit determined by deducting the cost of cultivation from gross monetary return (GMR). It is apparent that NMR increased with increases in seeding rate and decreases in sowing depths. However increase was not linear from S_1 to S_4 as NMR was highest in S_3. Such cost benefits and economics of wheat cultivation under different seeding rate and sowing depths were reported also by Kumar *et al.* (2002). Consequently the true monetary gain over each rupee of investment termed as benefit cost ratio was more in S_3 compared to other seeding rates.

Thus sowing at proper depth with optimal seed rates can enhance growth and net monetary return in wheat. We

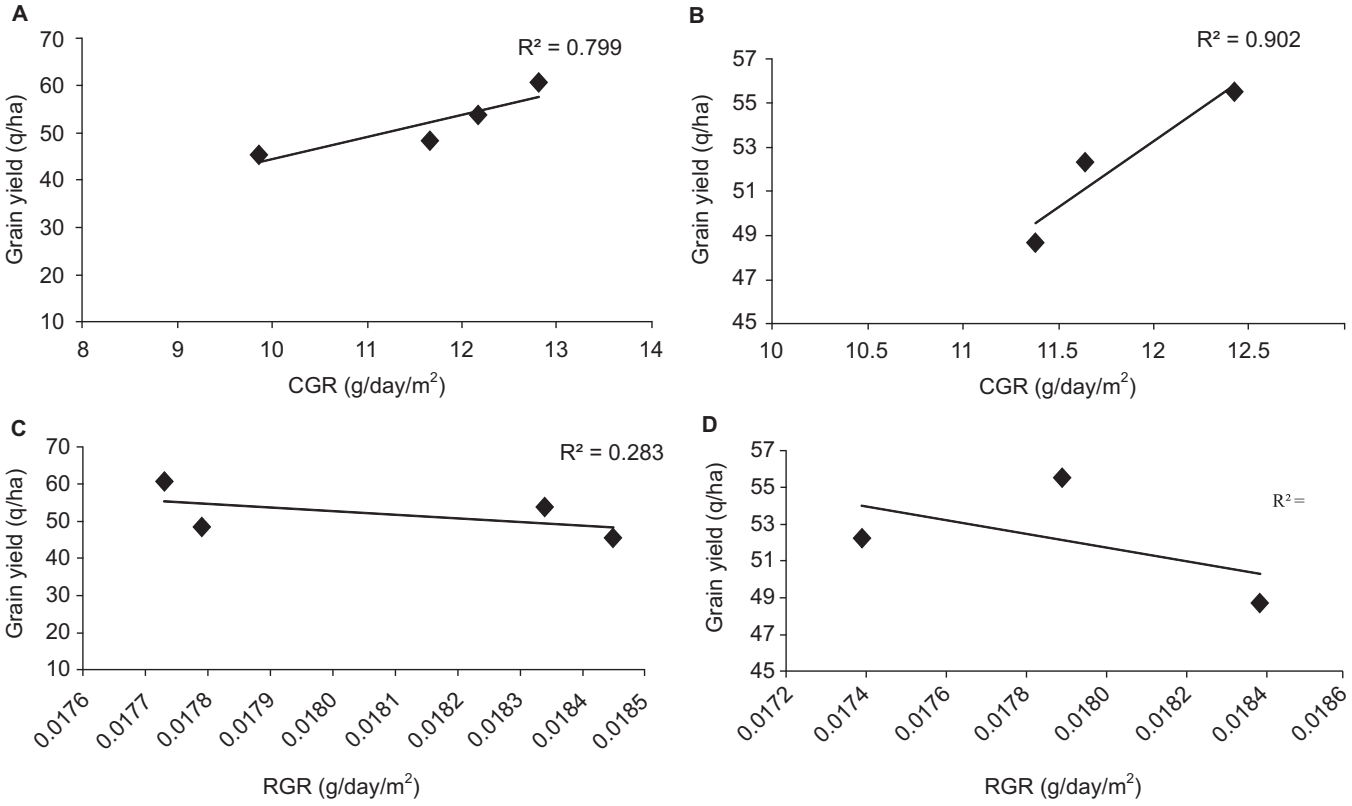

Fig 1 Relationship of grain yield with crop growth rate and relative growth rate under different seed rate (A and C) and sowing depth (B and D) respectively.

Table 2 Economics of the treatments of wheat as influenced by seed rates and depths of sowing

Treatment	Cost of cultivation (₹/ha)				Net monetary return (₹/ha)				B:C ratio			
	Sowing depths				Sowing depths				Sowing depths			
Seed rates	2 cm (D_1)	4 cm (D_2)	6 cm (D_3)	Mean	2 cm (D_1)	4 cm (D_2)	6 cm (D_3)	Mean	2 cm (D_1)	4 cm (D_2)	6 cm (D_3)	Mean
40 kg/ha (S_1)	19 415	19 415	19 415	19 415	51 007	40 563	38 066	43 212	3.41	2.89	2.74	3.00
60 kg/ha (S_2)	20 015	20 015	20 015	20 015	52 707	44 193	42 125	46 341	3.40	2.98	2.88	3.09
80 kg/ha (S_3)	20 615	20 615	20 615	20 615	59 723	61 297	59 448	60 156	3.67	3.75	3.66	3.69
100 kg/ha (S_4)	21 215	21 215	21 215	21 215	54 588	56 372	44 952	51 970	3.34	3.63	2.98	3.53
Mean	20 315	20 315	20 315		54 506	50 606	46 147		3.45	3.31	3.27	

Sale price of wheat seed and straw is ₹ 1 150/q and 100/q respectively.

conclude that seeds sown at surface (2 cm deep) with a seeding rate of 80 kg/ha enhanced the resilience and yield of wheat crop and can be used extensively in this part of Kymore Plateau and Satpura Hills agro-climatic zone of Madhya Pradesh.

SUMMARY

A field experiment was conducted during 2009-10 to investigate the effect of seed rates (40, 60, 80 and 100 kg/ha) and seeding depths (2, 4 and 6 cm) on growth, physiological parameters and economics in wheat (var GW 273). Study was carried out in agricultural farm Department of Agronomy, JNKVV, Jabalpur located in Kymore Plateau and Satpura Hills agro-climatic zone of Madhya Pradesh. As results indicate plant height, crop growth rate (CGR) and relative growth rates (RGR) increased significantly in 80 kg/ha seed rate as well as 2 cm sowing depth. The CGR was significantly correlated with grain yield with different seed rates as well as sowing depths. Results revealed that along with increases in CGR, seeds @ 80 kg/ha sown at 2 cm depth significantly increased dry matter production and grain yield in wheat. We conclude that these agronomical practices may prove to be

beneficial to enhance the resilience and yield of wheat crop in this part of the agro-climatic zone.

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