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Weed competitiveness and productivity of interplanted wheat cultivars under varying water management

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ABSTRACT

Growing two or more cultivars of the same crop species in mixture reduces intra-specific competition for growth resources by inducing variation in spatial and temporal patterns of crop growth, increases competitive ability of crops against weeds and thus enhances crop yield. This study was conducted to evaluate the potentiality of wheat cultivar mixtures to reduce weed growth and increase the wheat yield under different irrigation regimes, and determine the best row mixture ratio of two wheat cultivars for better weed suppression and higher productivity of wheat. Factors included seven cultivar mixture ratios *viz.* sole BARI Gom 25, sole BARI Gom 30, 1:2, 2:1, 2:3, 3:2 and 1:1 of BARI Gom 25 to BARI Gom 30, and three water management practices *viz.* no irrigation, one irrigation at crown root initiation (CRI) stage, and two irrigation at CRI and flowering stages arranged in a split-plot design with three replications. Results clearly indicated that cultivar mixture can improve the competitive ability of wheat plants against weeds and can increase wheat productivity. Both cultivars showed better growth, higher weed suppression and increased yield when grown in mixture irrespective of ratios compared to their monoculture. Based on the combined grain yield, different mixture ratios performed in the order 1:1, 2:3, 1:2 and 2:1 BARI Gom 25 to BARI Gom 30 under two irrigation regimes. BARI Gom 25 and BARI Gom 30 inter-planted in 1:1 row ratio under two irrigation appeared as the best practice resulting 9% and 5.83% yield advantages over sole culture of BARI Gom 25 and BARI Gom 30, respectively; while mixture ratio of 3:2 resulted in 6.43% and 3.36% weed dry matter reduction over sole culture of BARI Gom 25 and BARI Gom 30, respectively. In conclusion, cultivar mixture strategy can be adopted as an effective tool for better weed management and increased yield of wheat.

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Introduction

Wheat (*Triticum aestivum L.*) is the leading cereal of the world. In Bangladesh, it ranks the second after rice, and is grown in dry winter season (November-March) mostly using the residual soil moisture or as an irrigated crop with 1 or 2 supplementary irrigation. Due to its lower water requirement compared to boro (winter) rice, wheat is gaining much popularity among the farmers and gradually replacing boro rice in some areas where irrigation water is scarce (BBS, 2015). But high weed infestation because of dry soil condition is a limiting factor for wheat cultivation. Moreover, root system of wheat is too weak to compete with weeds and therefore wheat is highly vulnerable to weed infestation (Riya et al. 2017). Hossain et al. (2010) recorded 22 weed species belonging to 11-12 families infesting the wheat field. On the other hand, Shabi et al. (2018) and Riya et al. (2017) respectively reported 11 and 8 weed species from their wheat fields. Among the different pests, weed is the most important one reducing wheat yield by up to 50% depending upon the competitiveness of the varieties (Shabi et al. 2018). Hossain et al. (2010) observed that weed inflicted relative yield loss in wheat is highly variable, and may range from 17 to 51%. Dickson et al. (2011) recorded as high as 92% yield reduction in wheat due to ryegrass infestation. Therefore, weed infestation is a crucial problem in wheat cultivation and its proper management is of huge concern to ensure the potential yield of wheat. Manual method is the most effective means of weed control but it is a labor-intensive method and labor is becoming scarce and labor wages is also very high (Juraimi et al. 2013). As a result, chemical weed control is becoming popular day by day because of its high efficacy and cost effectiveness (Ahmed et al. 2011; Anwar et al. 2012a; Popy et al. 2017; Islam et al. 2018a). But continuous use of herbicide may result in development of herbicide resistance in crops and at the same time may cause environmental hazard (Anwar et al. 2010). Cultural weed control, a component of integrated weed management, is cost effective and also eco-friendly (Anwar et al. 2014; Hia et al. 2017). The cultural methods of weed control include cultivar mixture (Binang et al. 2011), intercropping (Rabeya et al. 2018), use of allelopathic crops (Samedani et al. 2013; Islam et al. 2018b), growing cover crops (Samedani et al., 2014), use of competitive variety (Anwar et al. 2010; Shabi et al. 2018), adjusting planting density (Anwar et al. 2011; Sunyob et al. 2012; Khan et al. 2017), seed priming (Anwar et al. 2012b), etc. All these methods limit the buildup of weed populations and favor the crop plants to fight against weeds.

Cultivar mixture is the practice of growing more than one cultivar of the same crop species simultaneously on the same land. Among other benefits, cultivar mixture gives the crop greater capacity to adjust under stress (Binang et al. 2010a,b). Previous studies have confirmed that cultivar mixture is an epidemic control strategy for disease (Rodriguez, 2006; Parisi, 2013) and lodging (Finckh et al. 2000), which leads to higher stability (Castilla et al. 2003). This strategy also can enhance functional diversity and improve yield by providing more chances for positive interactions among component cultivars (Bahani et al. 2014). Binang et al. (2011) reported that cultivars grown in mixture can reduce weed dry matter production by enhancing competitive ability of rice and thus diminish rice biomass losses. Estavan (2006) also confirmed that cultivar mixture could improve competitive ability of barley against weeds. The uses of cultivar mixtures thus are a potent supplement to present weed management practices and could reduce production costs and environmental pollution. But this weed management strategy has not been properly investigated with the popular high yielding wheat varieties under Bangladesh context.

Again among the inputs which are essential for production of crops, water is most important. Irrigation plays a vital role in terms of bringing good growth and development of wheat. Appropriate growth and development of wheat needs auspicious soil moisture in the root zone. Inadequate soil moisture affects both the germination of seed and uptake of nutrients from the soil. Irrigation frequency plays a significant role on growth and yield of wheat (Khajanij and Swivedi, 1988). On the other hand, excessive soil moisture is harmful and also conducive to weed invasions into crop fields. Shirazi (2014) found that 200 mm irrigation is the best treatment for production of wheat. Meena et al. (1998) and Atikullah (2014) reported that irrigation at root initiation and flowering stage has greater impact on growth and yield of wheat. Haghshenas et al. (2013) revealed that mixed culture of early- and middle-ripening wheat cultivars had the potential for altering the intensified competition under moisture stress. So far, we know there is no reported work on the effect of cultivar mixture and water management on the wheat growth and productivity. Therefore, it is necessary to evaluate cultivar mixture strategy and water management as tools of sustainable weed management and yield improvement in wheat. The present study was conducted to evaluate the effect of cultivar mixture ratio and water management on wheat growth and yield and to determine the best cultivar mixture ratio and water management for better weed suppression and higher wheat productivity.

Materials and Methods

Experimental site and duration

The experiment was conducted at the Agronomy Field Laboratory, Department of Agronomy, Bangladesh Agricultural University (24°75′ N latitude and 90°50′ E longitude and at an altitude of 18 m), Mymensingh, Bangladesh during November 2017 to April 2018. The soil of the studied area belongs to non-calcareous dark grey floodplain. The field was a medium high land having welldrained silty loam soil with pH 6.8. The climate of the experimental area is sub-tropical. During the growing season, monthly average temperature, relative humidity and solar radiation were 18.0–25.5 °C, 75-84% and 194.0–239.9 W m^{-2}, respectively, while monthly total rainfall and sunshine hours were 0–104.8 mm and 84.7–200 h, respectively. The soil temperature at a depth of 5, 10, 20 and 30 cm were 19.0–27.5, 19.6–27.4, 19.9–26.8 and 18.7–25.4°C, respectively.

Experimental treatments and design

The experiment included factor A: water management such as (i) no irrigation (ii) one irrigation at crown root initiation (CRI) stage and (iii) two irrigation at CRI and flowering stages and factor B: cultivar mixture row ratio (BARI Gom 25: BARI Gom 30) such as (i) 1:0 (ii) 1:2 (iii) 2:1 (iv) 2:3 (v) 3:2 (vi) 2:4 (vii) 4:2 (viii) 1:1 (ix) 0:1. The experiment was laid out in a spilt-plot design with three replications. Water management was assigned in main plot and cultivar mixture ratio in sub plot. Unit plot size was 4.0 × 2.5 m.

Plant materials

Two wheat cultivars BARI Gom 25 and BARI Gom 30 were used in this study. Both the cultivars were developed and released by Wheat Research Centre, Bangladesh Agricultural Research Institute (BARI). A brief description of the wheat cultivars is given in Table 1.

Table 1. Salient features of the wheat varieties used in this experiment.

Cultivar	Year of release	Plant height (cm)	Field duration (days)	Potential yield (t ha^{-1})
BARI Gom 25	2010	95-100	105-112	3.5-4.5
BARI Gom 30	2014	100-105	100-105	4.0-5.0

Crop husbandry

Seeds were sown (110 kg ha^{-1}) on 20 November 2017 maintaining the spacing 20 x 20 cm. The land was fertilized with urea, triple super phosphate (TSP), muriate of potash (MoP) and gypsum at the rate of 226, 150, 40 and 110 kg ha^{-1}, respectively. Half of urea and whole amount of other fertilizers were applied during final land preparation and rest of the urea was top dressed at 21 days after sowing (DAS). Weeding was done manually, twice at 20 DAS and 40 DAS. Irrigation was done as per experimental treatments.

Data collection

Five hills (excluding border hills) of each variety were selected randomly from unit plot prior to harvest to collect the data on yield contributing characters. Crop was harvested at full maturity (90% of the grains became matured). BARI Gom 30 was harvested on 11 March while BARI Gom 25 was harvested on 14 March. Grain yield, collected from the whole plot harvest, was adjusted to a moisture content of 14% and finally converted to t ha^{-1}. A quadrate of size 0.25 × 0.25 m was placed randomly in two places of each plot for collecting weed samples. Weeds were clipped to ground level, identified and counted by species, and separately oven dried at 70°C for 72 hours.

Dominant weed species were identified using the summed dominance ratio (SDR) computed as follows:

$$\text{SDR} = \frac{\text{Relative density (RD)+Relative dry weight (RDW)}}{2}$$

$$\text{Where, RD (\%)} = \frac{\text{Density of a given weed species}}{\text{Total weed density}} \times 100$$

$$\text{RDW (\%)} = \frac{\text{Dry weight of a given weed species}}{\text{Total weed dry weight}} \times 100$$

Statistical analysis

Collected data were compiled, tabulated and analyzed statistically. Analysis of variance was done following the split-plot design with the help of computer package MSTAT and the mean differences among the treatments were adjudged by Duncan's Multiple Range Test at 5% level of probability.

Results and Discussion

Performance of BARI Gom 25

Cultivar mixture ratio significantly affected number of spikelets $spike^{-1}$, grains $spike^{-1}$ and grain weight $hill^{-1}$, while water management significantly affected all the yield contributing characters and grain weight $hill^{-1}$ of BARI Gom 25 (Table 2). Interaction effect, on the other hand, was significant only for spikelets $spike^{-1}$ and grain weight $hill^{-1}$ (Table 3). BARI Gom 25 produced the highest grain weight $hill^{-1}$ (5.50 g) when grown with BARI Gom 30 in 1:1 row ratio which was the consequence of highest grains $spike^{-1}$. Sole culture of BARI Gom 25, on the other hand, resulted in the lowest grain weight $hill^{-1}$ (4.79 g) because of poor performances of the yield parameters. All the yield parameters increased gradually with the increasing frequency of irrigation. Amongst the water management treatments, three irrigation regimes resulted in the maximum grain weight $hill^{-1}$ (6.20 g) because of the best performances of all the yield contributing characters. No irrigation, on the other hand, produced the lowest grain weight hill^{-1} (4.18 g) due to the worst performances of the yield parameters. BARI Gom 25 and BARI Gom 30 inter planted in 1:1 ratio coupled with two irrigation produced the highest grain weight hill^{-1} (6.57 g) statistically followed by 3:2 and 2:3 inter planting row ratios when irrigated twice. Sole culture of BARI Gom 25 under no irrigation resulted in the lowest grain weight hill^{-1} (4.01 g). In general, two irrigation regimes irrespective of cultivar mixture ratio of BARI Gom 25 and BARI Gom 30 resulted in higher grain weight hill^{-1}. On the other hand, no irrigation irrespective of cultivar mixture ratio produced lower grain weight hill^{-1}.

Table 2. Effect of wheat cultivars mixture ratio and water management on yield contributing characters and yield of BARI Gom 25.

Treatment	No. of effective tillers hill^{-1}	No. of spikelets spike^{-1}	No. of grains spike^{-1}	1000- grain weight (g)	Grain weight hill^{-1} (g)
Cultivar mixture ratio (BARI Gom 25: BARI Gom 30)					
Sole BARI Gom 25	2.76	14.10d	39.39c	43.64	4.79d
1:2	2.76	15.81b	40.73bc	43.53	4.94c
2:1	2.81	15.11c	40.48bc	43.97	5.05c
2:3	2.82	15.67bc	41.66ab	43.97	5.20b
3:2	2.84	16.70 a	41.84ab	44.27	5.32b
1:1	2.84	16.70b	43.05a	44.46	5.50a
$S\bar{x}$	0.03	0.19	0.52	0.57	0.05
Level of significance	NS	**	**	NS	**
CV (%)	3.33	3.80	6.82	3.94	2.97
Water management					
No irrigation	2.60c	13.69b	36.96c	43.23b	4.18c
One irrigation	2.77b	16.47a	41.32b	43.67b	5.01b
Two irrigation	3.04a	16.47a	45.30a	45.02a	6.20a
$S\bar{x}$	0.022	0.139	0.371	0.408	0.036
Level of significance	**	**	**	**	**
CV (%)	3.33	3.80	6.82	3.94	2.97

In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** = Significant at 1% level of probability, NS = Not significant.

Table 3. Interaction effect of wheat cultivar mixture ratio and water management on yield contributing characters and yield of BARI Gom 25.

Interaction (Cultivar mixture ratio × water management)		No. of effective tillers hill^{-1}	No. of spikelets spike^{-1}	No. of grains spike^{-1}	1000- grain weight (g)	Grain weight hill^{-1} (g)
Sole BARI gom 25	No irrigation	2.63	11.73i	35.33	43.00	4.01i
	One irrigation	2.70	14.93ef	38.07	43.60	4.48g
	Two irrigation	2.96	15.63def	44.77	44.33	5.88c
(BARI gom 25: BARI gom 30) 1:2	No irrigation	2.63	13.70gh	35.40	43.20	4.05i
	One irrigation	2.70	16.07cde	41.10	42.73	4.74f
	Two irrigation	2.97	16.67bcd	45.70	44.67	6.04c
(BARI gom 25: BARI gom 30) 2:1	No irrigation	2.60	12.73h	37.33	43.23	4.24ghi
	One irrigation	2.77	16.03cde	39.83	43.67	4.83f
	Two irrigation	3.07	16.57bcd	44.27	45.00	6.10bc
(BARI gom 25: BARI gom 30) 2:3	No irrigation	2.60	13.77g	36.33	43.33	4.11hi
	One irrigation	2.80	15.70def	42.97	43.47	5.19e
	Two irrigation	3.07	17.53ab	45.67	45.10	6.31ab
(BARI gom 25: BARI gom 30) 3:2	No irrigation	2.60	15.60def	38.43	43.30	4.35gh
	One irrigation	2.83	17.03abc	42.07	44.17	5.26e
	Two irrigation	3.10	17.47ab	45.03	45.33	6.35ab
(BARI gom 25: BARI gom 30) 1:1	No irrigation	2.57	14.60fg	38.93	43.33	4.37gh
	One irrigation	2.86	15.66def	43.90	44.37	5.56d
	Two irrigation	3.10	18.03a	46.33	43.00	6.57a
$S\bar{x}$		0.055	0.341	0.909	1.002	0.088
Level of significance		NS	**	NS	NS	**
CV (%)		3.33	3.80	6.82	3.94	2.97

In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** = Significant at 1% level of probability, NS = Not significant.

Performance of BARI Gom 30

Cultivar mixture ratio significantly affected number of spikelets spike^{-1}, grains spike^{-1} and grain weight hill^{-1}, while water management significantly affected all the yield contributing characters and grain weight hill^{-1} of BARI Gom 30 (Table 4). Interaction effect, on the other hand, was significant for spikelets spike^{-1}, grains spike^{-1} and grain weight hill^{-1} (Table 5). BARI Gom 30 produced the highest grain weight hill^{-1} (6.44 g) when grown with BARI Gom 25 in 1:1 row ratio because of the highest grains spike^{-1}. Sole culture of BARI Gom 30, on the other hand, resulted in the lowest grain weight hill^{-1} (5.66 g) which was consequence of poor performances of the yield parameters. All the yield parameters increased gradually with the increasing frequency of irrigation. Amongst the water management treatments, three irrigation regimes produced the maximum grain weight hill^{-1} (7.25 g) because of the best performances of all the yield parameters. No irrigation, on the other hand, resulted in the lowest grain weight hill^{-1} (4.90 g) which was the consequence of the worst performances of the yield parameters. BARI Gom 25 and BARI Gom 30 inter planted in 1:1 interacted favorably to produce the highest grain weight hill^{-1} (7.57 g) statistically followed by 3:2 and 2:3 row ratios coupled with two irrigation. Sole culture of BARI Gom 30 under no irrigation resulted in the lowest grain weight hill^{-1} (4.70 g). General observation was that, irrespective of cultivar mixture ratio of BARI Gom 25 and BARI Gom 30, two irrigation regimes resulted in higher grain weight hill^{-1}. On the other hand, no irrigation produced lower grain weight hill^{-1} irrespective of cultivar mixture ratio.

Table 4. Effect of wheat cultivar mixture ratio and water management on yield contributing characters and yield of BARI Gom 30.

Treatment	No. of effective tillers hill^{-1}	No. of spikelets spike^{-1}	No. of grains spike^{-1}	1000-grain weight (g)	Grain weight hill^{-1} (g)
Cultivar mixture ratio (BARI Gom 25: BARI Gom 30)					
Sole BARI Gom 30	3.13	14.43d	40.40d	44.46	5.66d
1:2	3.13	16.15b	41.78bc	44.38	5.85c
2:1	3.18	15.44c	41.43cd	44.79	5.95c
2:3	3.19	16.00bc	42.70b	44.80	6.14b
3:2	3.21	17.03a	42.88ab	45.11	6.27ab
1:1	3.21	16.32b	43.87a	45.30	6.44a
$S\bar{x}$	0.023	0.205	0.374	0.579	0.062
Level of significance	NS	**	**	NS	**
CV (%)	2.23	3.87	4.67	3.88	4.07
Water management					
No irrigation	2.90c	13.99b	38.16c	44.03b	4.90c
One irrigation	3.17b	16.86a	42.52b	44.47b	6.00b
Two irrigation	3.44a	16.83a	45.84a	45.92a	7.25a
$S\bar{x}$	0.017	0.145	0.264	0.410	0.044
Level of significance	**	**	**	**	**
CV (%)	2.23	3.87	4.67	3.88	4.07

In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** = Significant at 1% level of probability, NS = Not significant.

Table 5. Interaction effects of wheat cultivar mixture ratio and water management on yield contributing characters and yield of BARI Gom 30.

Interaction (Cultivar mixture ratio ×water management)		No. of effective tillers hill^{-1}	No. of spikelets spike^{-1}	No. of grains spike^{-1}	1000-grain weight (g)	Grain weight hill^{-1} (g)
Sole BARI Gom 30	No irrigation	2.93	12.03i	36.53i	43.80	4.70j
	One irrigation	3.10	15.33ef	39.27fgh	44.40	5.40gh
	Two irrigation	3.37	15.93def	45.40ab	45.17	6.90cd
(BARI Gom 25: BARI Gom 30) 1:2	No irrigation	2.93	14.00gh	36.60i	44.00	4.75j
	One irrigation	3.10	15.47def	42.30de	43.53	5.70fg
	Two irrigation	3.37	16.97bcd	46.43a	45.60	7.12bc
(BARI Gom 25: BARI Gom 30) 2:1	No irrigation	2.90	13.03hi	38.53ghi	44.03	4.96ij
	One irrigation	3.17	16.43cde	41.03ef	44.47	5.79f
	Two irrigation	3.47	16.87bcd	44.73abc	45.87	7.10bc
(BARI Gom 25: BARI Gom 30) 2:3	No irrigation	2.90	14.07gh	37.53hi	44.13	4.82ij
	One irrigation	3.20	16.10de	44.17bcd	44.27	6.21e
	Two irrigation	3.47	17.83ab	46.40a	46.00	7.39ab
(BARI Gom 25: BARI Gom 30) 3:2	No irrigation	2.90	15.90def	39.63fg	44.10	5.09hi
	One irrigation	3.23	17.43abc	43.27cd	44.97	6.29e
	Two irrigation	3.50	17.77ab	45.73ab	46.27	7.43ab
(BARI Gom 25: BARI Gom 30) 1:1	No irrigation	2.87	14.90fg	40.13fg	44.13	5.12hi
	One irrigation	3.27	15.63ef	45.10abc	45.17	6.63d
	Two irrigation	3.50	18.43a	46.37a	46.60	7.57a
$S\bar{x}$		0.041	0.355	0.648	1.00	0.108
Level of significance		NS	**	**	NS	*
CV (%)		2.23	3.87	4.67	3.88	4.07

In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant.

Total Yield

Total grain yield was significantly affected by the combined effect of cultivar mixture ratio and water management (Table 6). The grain yield was found the highest (3.63 t ha^{-1}) when BARI Gom 25 and BARI Gom 30 were interplanted in 1:1 ratio following two irrigation; sole culture of either BARI Gom 25 or BARI Gom 30 and their all mixture ratios resulted in statistically similar grain yield when two irrigations were provided. On the other hand, sole culture of BARI Gom 25 under no irrigation yielded the lowest (1.76 t ha^{-1}) which was statistically similar to those produced by sole BARI Gom 30 and all the mixture ratios coupled with no irrigation.

Table 6. Interaction effects of wheat cultivar mixture ratio and water management on total grain yield

Interaction (Cultivar mixture ratio × water management)		Grain yield (t ha^{-1})
Sole BARI Gom 25	No irrigation	1.76f
	One irrigation	2.71e
	Two irrigation	3.33abcd
Sole BARI Gom 30	No irrigation	1.81f
	One irrigation	2.83e
	Two irrigation	3.43abc
(BARI Gom 25: BARI Gom 30) 1:2	No irrigation	1.90f
	One irrigation	2.90de
	Two irrigation	3.51ab
(BARI Gom 25: BARI Gom 30) 2:1	No irrigation	1.95f
	One irrigation	2.87de
	Two irrigation	3.44abc
(BARI Gom 25: BARI Gom 30) 2:3	No irrigation	2.03f
	One irrigation	3.03cde
	Two irrigation	3.03cde
(BARI Gom 25: BARI Gom 30) 3:2	No irrigation	1.94f
	One irrigation	2.90de
	Two irrigation	3.51ab
(BARI Gom 25: BARI Gom 30) 1:1	No irrigation	2.18f
	One irrigation	3.10bcde
	Two irrigation	3.63a
$S\bar{x}$		0.146
Level of significance		**
CV (%)		9.10

In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** = Significant at 1% level of probability

Weed Species Composition

Eleven weed species belonging to eight different families were observed in experimental field, among which seven were broadleaved, three grasses and one sedge (Table 7). Weed community was mostly dominated by grasses followed by broadleaved and sedges. Based on the summed dominance ratio (SDR), the most dominant weed species encountered was *Digitaria sanguinalis* followed by *Polygonum hydropiper* and *Chenopodium album.*

Weed Density

Weed density was significantly affected by wheat cultivar mixture, water management and their interaction (Table 8 and Table 9). The lowest weed density was observed when BARI Gom 25 and BRRI Gom 30 were planted in 3:2 ratio, while sole BRRI Gom 25 resulted in highest weed density. No irrigation condition resulted in the highest weed density (128.6 g m^{-2}) while lowest one (124. 2 g m^{-2}) was recorded under two irrigation condition. One irrigation irrespective of cultivar mixture ratios resulted in lower weed density compared to other interactions. Irrigation twice coupled with any cultivar mixture ratio, on the contrary resulted in very high weed density.

Table 7. Dominant weed species with family name, type, relative density (RD), relative dry weight (RDW) and summed dominance ratio (SDR).

Scientific name	Family name	Weed type	RD (%)	RDW (%)	SDR
Digitania sanguinalis	Gramineae	Grass	142.3	50.7	46.50
Polygonum hydropiper	Polygonaceae	Broad leaf	13.8	10.4	12.10
Chenopodium album	Chenopodiaceae	Broad leaf	10.8	7.8	9.30
Hedyotis corymbosa	Rubiaceae	Broad leaf	8.6	7.9	8.25
Echinochloa colonum	Gramineae	Grass	7.1	5.2	6.15
Echinochloa crusgali	Gramineae	Grass	5.4	5.1	5.25
Solanum toryum	Solanaceae	Broad leaf	3.6	6.2	4.90
Physalis haterophylla	Solanaceae	Broad leaf	3.3	4.8	4.05
Vicia sativa	Leguminoceae	Broad leaf	2.8	1.0	1.90
Cyperus rotundus	Cyperaceae	Sedge	1.4	0.7	1.05
Oxalis curopaea	Oxalidaceae	Broad leaf	0.9	0.2	1.05

Table 8. Effect of wheat cultivars mixture ratio and water management on weed density and dry weight.

Treatment	Weed density (no.m^{-2})	Weed dry weight (g m^{-2})
Cultivar mixture ratio (BARI gom 25: BARI gom 30)		
Sole BARI gom 25	132.1a	61.78a
Sole BARI gom 30	127.9b	57.56b
1:2	126.8b	56.44b
2:1	126.7b	56.33b
2:3	126.7b	56.33b
3:2	123.6c	53.22c
1:1	126.0bc	55.67b
$S\bar{x}$	. 0995	0.842
Level of significance	**	**
CV (%)	12.35	9.45
Water management		
No irrigation	128.6a	48.57c
One irrigation	125.1b	56.14b
Two irrigation	124.2b	65.57a
$S\bar{x}$	0.651	0.551
Level of significance	**	**
CV (%)	12.35	9.45

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** = Significant at 1% level of probability.

Weed Dry Matter

Weed dry matter was significantly affected by cultivar mixture ratio, water management and their interaction (Table 8 and Table 9). Maximum weed dry matter of 61.78 g m^{-2} was recorded from sole BRRI Gom 25. On the other hand, all the mixture ratios resulted in similar (ranged from 53.22 to 56.44 g m^{-2}) weed dry matter, which was significantly lower than those recorded from monoculture of BARI Gom 25 or BRRI Gom 30. Weed dry matter was found the highest (65.57 g m^{-2}) in two irrigation treatment, and gradually decreased with the decrease in frequency of irrigation. Weed dry matter varied from 42.67 to 73.67 gm^{-2} among different interactions of cultivar mixture ratio and water management. No irrigation treatment irrespective of cultivar mixture ratios resulted in lower weed dry matter compared to other interactions. Two irrigation treatment coupled with any cultivar mixture ratio produced very high weed dry matter.

Cultivation of two or more cultivars of the same crop species in mixture increases crop productivity through improved functional diversity and positive interactions between component cultivars and thus ultimately increases system efficiency. Advantages of cultivar mixture include yield stabilization, higher resource utilization and better weed, pest and disease management. It was therefore hypothesized that growing of two wheat cultivars in mixture will result in better weed suppression, higher utilization of irrigation water and ultimately increased productivity. In the present study, two high yielding wheat cultivars namely BARI Gom 25 and BARI Gom 30 were inter-planted in different row ratios under varying water management practices to evaluate their yield performance under different water management. Both the cultivars had very similar plant stature, growth duration and yield potential.

In this study, grain weight $hill^{-1}$ of both the varieties was significantly influenced by cultivar mixture ratio. All the mixture ratios produced higher grain weight $hill^{-1}$ compared to that of respected sole culture, and for both the cultivars mixture ratio of 1:1 resulted in the highest grain weight $hill^{-1}$ which was the consequence of the cumulative performance of both number of spikelets $spike^{-1}$ and number of grains $spike^{-1}$. Several mechanisms are believed to be responsible for the yield advantages in cultivar mixture like compensatory effects between component cultivars with different competitive abilities (Fukai and Trenbath, 1993), complementary use of resources (Willey, 1979) and facilitation effect of one cultivar on the growth of other cultivar (Garcia-Barrios, 2003). In case of compensation, yield of one cultivar increases while the other decreases without affecting combined yield when grown in mixtures (Khalifa and Qualset, 1974). Here, the most applicable mechanism is complementary use of resources by the component cultivars. In cultivar mixture, overall use of above- and below-ground resources are better than sole culture of any of the component cultivar, and this occurs only when component cultivars differ in their resource use in terms of space and time (Fukai and Trenbath, 1993).

Table 9. Interaction effects of wheat cultivar mixture ratio and water management on yield contributing characters and yield of BARI Gom 25 and BARI Gom 30.

Interaction (Cultivar mixture ratio × water management)		Weed density (no. m^{-2})	Weed dry weight (g m^{-2})
Sole BARI Gom 25	No irrigation	134.0ab	54.00 fgh
	One irrigation	126.7cdef	57.67ef
	Two irrigation	135.7a	73.67a
Sole BARI Gom 30	No irrigation	129.7bcde	49.67hi
	One irrigation	127.3cdef	58.33ef
	Two irrigation	126.7cdef	64.67bcd
(BARI Gom 25: BARI Gom 30) 1:2	No irrigation	131.7abc	51.67ghi
	One irrigation	123.3fg	54.33fg
	Two irrigation	125.3defg	63.33cd
(BARI Gom 25: BARI Gom 30) 2:1	No irrigation	125.0defg	45.00jk
	One irrigation	124.3efg	55.33fg
	Two irrigation	130.7abcd	68.67b
(BARI Gom 25: BARI Gom 30) 2:3	No irrigation	122.7fg	42.67k
	One irrigation	127.7cdef	58.67ef
	Two irrigation	129.7bcde	67.67bc
(BARI Gom 25: BARI Gom 30) 3:2	No irrigation	127.7cdef	47.67ij
	One irrigation	120.3g	51.33ghi
	Two irrigation	122.7fg	60.67de
(BARI Gom 25: BARI Gom 30) 1:1	No irrigation	129.3bcde	49.33ij
	One irrigation	126.3cdef	57.33ef
	Two irrigation	122.3fg	60.33de
$S\bar{x}$		1.72	1.45
Level of significance		**	**
CV (%)		12.35	9.45

In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). ** = Significant at 1% level of probability.

Water management positively influenced all the yield contributing characters of both the cultivars and two irrigation regimes showed the best performances which ultimately translated into the highest grain weight hill^{-1}. And, cultivar mixture ratio of 1:1 interacted favorably with two irrigations to produce the highest grain weight hill^{-1}. Positive influence of irrigation on the grain yield of wheat has been documented earlier by many researchers (Singh and Jain, 2000; Shirazi, 2011; Atikullah, 2014). In dry season, soil moisture content gradually decreases with time and simultaneously soil moisture tension increases. Extractable water capacity of soil has tremendous influence on wheat growth and productivity (Arora et al. 2007). Excessive irrigation, on the other hand increases evapotranspiration and decreases water use efficiency and may also reduce grain yield (Sun et al. 2006). Therefore, irrigation scheduling is very important to ensure proper soil moisture at critical grow stages of wheat crop. In Bangladesh, wheat is grown in the driest months of the year when there is almost no rainfall. Water balance analysis at the Mymensingh region of Bangladesh portrays that during wheat growing period potential evapotranspiration is higher than precipitation (Shirazi, 2014). And therefore, irrigation especially at crown root initiation and flowering stages is necessary to achieve the potential yield of wheat crop during this period.

As shown in the present study, cultivar mixture significantly reduced both weed density and dry weight compared to sole culture of either cultivar. BARI Gom 25 and BARI Gom 30 grown in 3:2 ratio resulted in the highest weed suppression. Similar findings have been reported by many others (Rodriguez, 2006; Binang et al. 2011) who revealed that cultivars when grown in mixture can decrease weed dry weight by enhancing competitive ability of component cultivars. Jedel et al. (1988) opined that cultivar grown in mixture produced taller plants than sole culture due to intra-specific competition for resources. Better weed suppression by taller plants than dwarf plants has been confirmed by many researchers (Anwar et al. 2010; Rahman et al. 2017; Arefin et al. 2018; Shabi et al. 2018). Although in this study, mixture ratio had no effect on plant height of either of the cultivars, but plant height was recorded numerically higher in mixture than in sole culture (data not shown). In case of water management, it was found that weed dry weight increased gradually with the increasing frequency of irrigation. This was mostly due to the fact that high water availability in case of two irrigation regimes favored weed growth.

Conclusion

Present study confirms the necessity of two irrigation (one at crown root initiation and another at flowering stages), and the advantages of inter-planting BARI Gom 25 and BRRI Gom 30 in terms of weed suppression and productivity over their sole culture. Therefore, cultivar mixture could be adopted as a sustainable tool for increased productivity in wheat. BARI Gom 25 and BRRI Gom 30 inter-planted in 1:1 row ratio is the best mixture ratio for highest productivity while 3:2 ratio performed as the most weed suppressive one. However, further site specific detail studies considering different agronomic aspects are required before final recommendation.

Conflict of Interest

Authors declare no conflict of interest.

References

Ahmed S, Islam M.R, Alam M.M, Haque M.M, Karim A.J.M.S. 2011. Rice production and profitability as influenced by integrated crop and resources management. Eco-Friendly Agric. 11: 720-725.

Anwar M.P, Juraimi A.S, Puteh A, Selamat A, Man A, Hakim M.A. 2011. Seeding method and rate influence on weed suppression in aerobic rice. Afric J Biotechnol. 10: 15259-15271.

Anwar M.P, Juraimi A.S, Man A, Puteh A, Selamat A, Begum M. 2010. Weed suppressive ability of rice (*Oryza sativa* L.) germplasm under aerobic soil conditions. Austra J Crop Sci. 4: 706-717.

Anwar M.P, Juraimi A.S, Samedani B, Mohamed M.T.M, Uddin M.K, Hasan A.K, Hossain M.D. 2014. Integrating cultural and chemical control methods for higher weed control efficiency and better performance of aerobic rice. Res Crops. 15: 1-13.

Anwar M.P, Juraimi A.S, Puteh A, Man A, Rahman M.M. 2012a. Efficacy, phytotoxicity and economics of different herbicides in aerobic rice. Acta Agric Scand. 62: 604-615.

Anwar M.P, Juraimi A.S, Puteh A, Selamat A, Rahman M.M, Samedani B. 2012b. Seed priming influences weed competitiveness and productivity of aerobic rice. Acta Agric Scand. 62: 499-509.

Arefin M.A, Rahman M.R, Anwar M.P. 2018. Weed competitiveness of winter rice (*Oryza sativa*) under modified aerobic system. Arch Agric Environ Sci. 3: 1-14.

Arora V.K, Singh H, Singh B. 2007. Analyzing Wheat Productivity Responses to Climatic, Irrigation and Fertilizer-Nitrogen Regimes in a Semi-arid Sub-tropical Environment Using the CERES-Wheat Model. Agric Water Manag. 94: 22-30.

Atikullah M.N. 2014. Effect of Irrigation Levels on Growth, Yield Attributes and Yield of Wheat. J Biosci Agric Res. 2: 83-89.

Bahani F.A, Pirdashti H, Niknejhad Y. 2014. Effect of rice cultivar mixture on paddy yield and yield componenets under different nitrogen levels. Int J Farming Allied Sci. 3: 317-319.

BBS (Bangladesh Bureau of Statistics). 2015 Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bur. Stat. Div., Mins. Plan., Govt. Peoples Repub. Dhaka, Bangladesh.

Binang W.B, Ekeleme F, Nita J.D. 2011. Management of Weeds of Rainfed Lowland Rice Using Cultivar Mixture Strategies. Asian J Agric Res. 5: 306-311.

Binang W.B, Okapara D.O, Nita J.D, Shiyam J.O. 2010a. Spatial and temporal deployment of cultivar effects on rice cuitivar mixtures. Res J Agric Biol Sci. 6: 1099-1102.

Binang W.B, Okapara D.O, Nita J.D, Shiyam J.O. 2010b. Evaluation of Cultivar Interplanting Ratio on the Productivity of Rice/Rice System. Res J Agric Biol Sci. 6: 1055-111059.

Castilla N.P, Vera-Cruz C.M, Mew T.W, Zhu Y. 2003. Using rice cultivar mixtures: a sustainable approach for managing diseases and increasing yield. Int Rice Res Institute. 7 pp.

Chadha K.L, Leela D, Challa P. 1997. Weed Management in Horticulture and Plantation Crops. Malhotra Publishing House, New Delhi, India. 230 p.

Dickson J.W, Scott R.C, Burgos N.R, Salas R.A, Smith K.I. 2011. Confirmation of glyphosate-resistant Italian ryegrass (*Lolium perenne* ssp. *multiflorum*) in Arkansas. Weed Tec. 25: 674-679.

Estavan E. 2006. Effect of cultivar mixture on the competitive ability of barley against weed. M.Sc. Thesis, Lincoln College, University Uppsala, Sweden.

Finckh M.R, Gacek E.S, Goyeau H, Lannou C, Merz U, Munndt C.C, Munk L, Nadziak J, Newoton A.C, de-Vallavieille-Pope C, Wolfe M.S. 2000. Cereal cultivar and species mixture in practice. Agronomie, 20: 813-837.

Fukai S, Trenbath B.R. 1993. Processes determining intercrop productivity and yields of component crops. Field Crops Res. 34: 247-271.

Gracia-Barrios L. 2003. Plant-Plant Interactions in Tropical Agriculture. In: *Tropical Agroecosystems.* Vandermeer J (Ed.), CRC Press, Boca Raton, Florida. pp. 11-58.

Haghshenas A, Emam Y, Ghadiri H, Kazemeini S.A, Haghighi A.A. 2013. Effect of mixed cropping of an aerly and middle ripening wheat cultivar on mitigation of competition during post-anthesis moisture stress. J Agric sci Technol. 15: 491-503.

Hia M.A.U.H, Islam A.K.M.M, Sarkar S.K, Anwar M.P. 2017. Effectiveness of integrated weed management in five varieties of aromatic rice in Bangladesh. Archives Agric Environ Sci. 2: 308-314.

Hossain A, Chowdhury M.A.S, Jahan T, Sarker M.A.I, Akhter M.M. 2010. Competitive ability of wheat cultivars against weeds. Bangladesh J Weed Sci. 1: 65-72.

Islam A.K.M.M, Hia M.A.U.H, Sarkar S.K, Anwar M.P. 2018a. Herbicide based weed management in aromatic rice of Bangladesh. J Bangladesh Agric Uni. 16: 31-40.

Islam A.K.M.M, Yeasmin S, Qasem J.R.S, Juraimi A.S, Anwar M.P. 2018b. Allelopathy of medicinal plants: current status and future prospects in weed management. Agric Sci. 9: 1569-1588.

Jedel K.W, Mackill D.J, Colowit P.M, Payne R.W. 1988. Competitive ability in Mixtures of small grain cereals. J Plant Sci. 59: 1010-1116.

Juraimi A.S, Uddin M.K, Anwar M.P, Mohamed M.T.M, Ismail M.R, Man A. 2013. Sustainable weed management in direct seeded rice culture: A review. Austr Jo Crop Sci. 7: 989-1002.

Khajanij S.N, Swivedi R.K. 1988. Response of wheat (*Triticum aestivum* L.) to irrigation and fertilizer mixture under late condition. Bhartiya Krishi Anusandhan Patrika, 3: 37-42.

Khalifa M.A, Qualset C.O. 1974. Intergenotypic competition between tall and dwarf wheats. I. In mechanical mixtures. Crop Sci. 14: 795-799.

Khan M.Z.K, Hasan A.K, Anwar M.P, Islam M.M. 2017. Weeding regime and plant spacing influence on weed growth and performance of transplant aman rice variety Binadhan-7. Fund Appl Agric. 2: 331-339.

Meena B.S, Gautam R.C, Kaushik S.K. 1998. Pearlmillet (*Pennlsetum glaucum*) and wheat (*Triticum aestivum*) cropping sequence as influenced by cultural, nutritional and irrigation factors under limited moisture conditions. Ind J Agric Sci. 68: 638-643.

Parisi L, Grosa C, Combe F, Parveaud C, Gomez C, Brun L. 2013. Impact of a cultivar mixture on scab, powdery mildew and rosy aphid in an organic apple orchard. Crop Prot. 43: 207-212.

Popy F.S, Islam A.K.M.M, Hasan A.K, Anwar M.P. 2017. Integration of chemical and manual control methods for sustainable weed management in inbred and hybrid rice. J Bangladesh Agric Uni. 15: 158-166.

Rabeya M.I, Anwar M.P, Rahman M.M, Akhter A, Islam A.K.M.M. 2018. Intercropping of dry direct seeded boro rice with leafy vegetable for better weed suppression and higher profitability. Fund Appl Agric. 3: 545–558.

Rahman A.N.M.A, Islam A.K.M.M, Arefin M.A, Rahman M.R, Anwar M.P. 2017. Competitiveness of winter rice varieties against weed under dry direct seeded conditions. Agric Sci. 8: 1415-1438.

Riya R.R, Bhuiya M.S.U, Anwar M.P. 2017. Weed interference period and seed rate influence on wheat productivity. Fund Appl Agric. 2: 218-226.

Rodriguez E.E. 2006. Effect of cultivar mixture on the competitive ability of barley against weed. M.Sc. Thesis. Swedish University of Agricultural Sciences. 29 pp.

Samedani B, Juraimi A. S, Yusop M.R, Rahim A.A, Abdullah S.A.S, Anwar M.P. 2013. Allelopathic effects of litter *Axonopus compressus* against two weedy species and its persistence in soil. The Sci World J. 1-8.

Samedani B, Juraimi A. S, Abdullah S.A.S, Yusop M.R.B, Rahim A.A, Anwar M.P. 2014. Effect of cover crops on weed community and oil palm yield. Int J Agric Biol. 16: 23-31.

Shabi T.H, Islam A.K.M.M, Hasan A.K, Juraimi A.S, Anwar M.P. 2018. Differential weed suppression ability in selected wheat varieties in Bangladesh. Acta Scientifica Malaysia. 2: 1-7.

Singh A.K, Jain G.L. 2000. Effect of Sowing Time, Irrigation and Nitrogen on Grain Yield and Quality of Durum Wheat (*Triticum durum*). Ind J Agric Sci. 70: 532.

Singh G, Singh S, Singh J. 2002. Optimization of energy inputs in wheat crop in Punjab. Energy Convers Manag. 45: 453-465.

Shirazi S.M. 2014. Effect of Irrigation Resimes and Nitrogen Levels on the Growth and Yield of Wheat. Adv Agric. 1-6.

Shirazi S.M. 2011. Effects of Different Irrigation Regimes and Nitrogenous Fertiliser on Yield and Growth Parameters of Maize. Int J Physic Sci. 6: 677-683.

Sun H.Y, Liu C.M, Zhang X.Y, Shen Y.J, Zhang Y.Q. 2006. Effects of Irrigation on Water Balance, Yield and WUE of Winter Wheat in the North China Plain. Agric Water Manag. 85: 211.

Sunyob N.B, Juraimi A.S, Rahman M.M, Anwar M.P, Man A, Selamat A. 2012. Planting geometry and spacing influence weed competitiveness of aerobic rice. J Food Agric Environ. 10: 330-336.

Willey R.W. 1979. Intercropping - its importance and research needs. Part 2. Agronomy and research approaches. Centro International de Mejoramiento de Maíz y Trigo, (CIMMYT), México CIMMYT Biblioteca. 2: 74-76.

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